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GROYNES OF REINFORCED CONCRETE TO CHECK COAST EROSION.

By J. B. Van Brussel.

The question of coast erosion is a serious one for many coast towns in England. One of the worst sufferers in the past has been Brighton, a city of some quarter of a million people. Near Brighton rise chalk cliffs to a height of about 120 feet, and large masses of these have from time to time been brought down during or after storms. A drift of the ocean along the coast from west to east scours the shore, keeping it low and leaving the cliffs unprotected when heavy seas roll in. The position has been rendered acute as the disintegration of the cliffs is threatening a large main sewer, which must be protected at any cost.

A system of protection by means of reinforced concrete groynes has been decided on. At present six of these groynes are to be built. They extend from the base of the cliff to low-water mark, a distance of about 548 feet, and are spaced 500 feet apart. They are of the low adjustable or Case type, and are placed at right angles to the shore line. The entire work is in Hennebique ferro-concrete. Each groyne consists of columns 16 inches square, spaced 5 feet 6 inches apart center to center for the first 200 feet from the cliff, and from thence to low water the centers are 7 feet apart. The spaces between the columns are closed by slabs, 6 inches thick and 1 foot deep, which drop into position in grooves molded in the sides of the columns. The slabs are fixed in their grooves by grouting, as the hard chalk foreshore renders provision for lowering the slabs unnecessary. The columns are fixed in holes excavated in the solid chalk and stand 8 feet clear of the chalk near the cliffs, gradually reducing in height to 2 feet 6 inches at low-water mark. This method of fixing the columns in the shore was adopted in view of the excellent nature of the foundation. In shores of sand or soft, easily-eroded material, the piles would need to be driven to a depth of 8 feet to 12 feet. Where the columns exceed 5 feet in height above the chalk they are strutted on the east side by struts 10 inches square, having their lower ends fixed in concrete in a similar way to the columns. Not more than two or three slabs above the shore level are inserted as the groynes are erected; but it is proposed to add other slabs as the shore builds up, the height being kept at about 2 feet or 3 feet above the shore level.

All reinforcements are of round-section steel. The concrete for the columns and slabs is made from shingle and sand obtained on the foreshore; an excellent supply of clean, angular, flint shingle and grit being available on the site. The proportions used are: Ballast, 27 cubic feet; sand, 13½ cubic feet; and cement, 7 cubic feet.

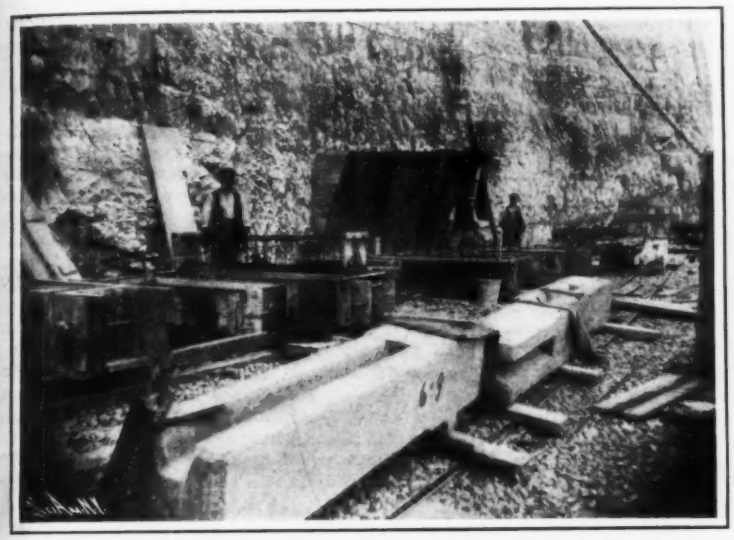
All ballast must pass a ¾ inch mesh, and all concrete is mixed with fresh water, no sea water being used. The columns and slabs are molded on the shingle at the base of the cliff, the molds being struck after twenty-four hours, after which they are allowed to season for about a month before being placed in the work. The work of erection was commenced at the most easterly groyne, owing to the prevailing drift being from the west, and a period of five months was allowed for completion, which promises to be ample. Three groynes are now completed, and there is a very satisfactory tendency for sand to collect between them.

In erecting, the contractors laid down a light railway parallel to the line of each groyne. The holes for the columns were excavated in the chalk, 3 feet square and from 2 feet 6 inches to 4 feet deep. The columns were then run down and lowered into position in the holes by a small crane, and the concrete rammed in around them. The holes were kept as small as would permit a man to work in them, and were filled to the shore level with concrete. No difficulty was experienced in fixing the columns plumb and in correct line.

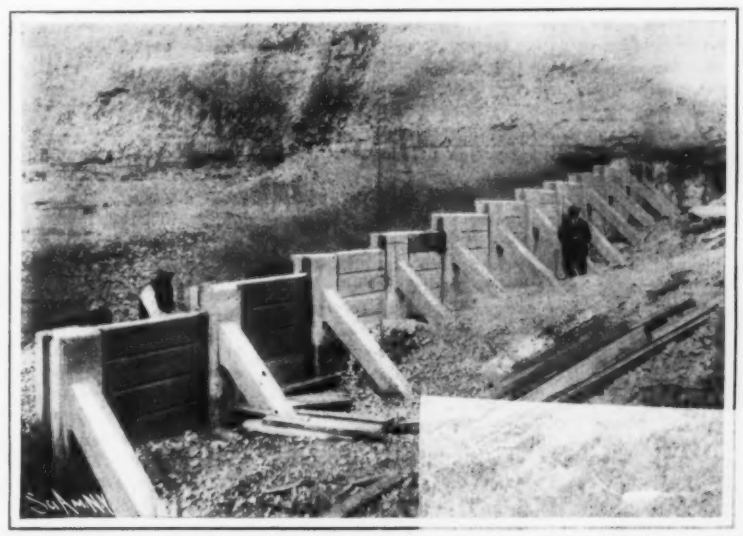
Where struts were provided, the steel work of the columns and struts was left exposed above the junction, and when in their correct position relative to each other a timber casing was cramped on, and the concrete rammed in. This method will enable repairs to be made with a minimum of labor and expense.

All that is necessary is to expose the steel work, box in the injured part, and ram in fresh concrete.

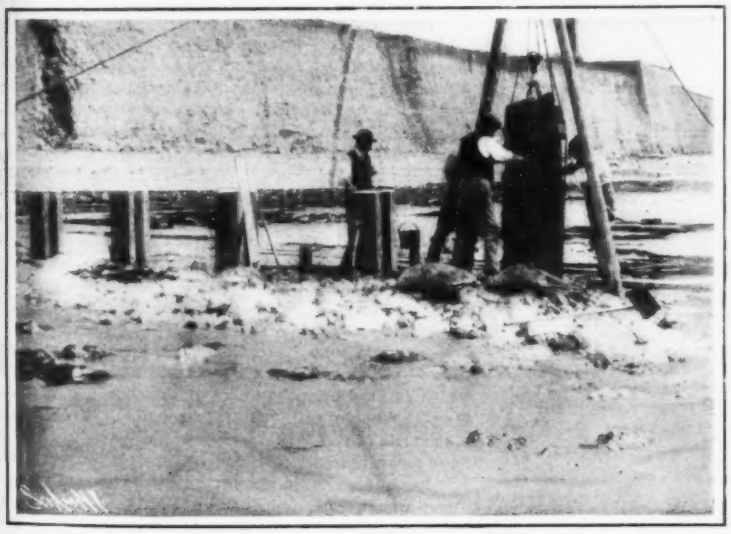
The work is done by contract at a cost which works



THE WORK IS ALL DONE AT THE BASE OF THE CLIFFS; USING LOCAL BALLAST.



THE GROYNES RUN AT RIGHT ANGLES FROM THE CLIFFS TO LOW WATER MARK.



THE POSTS ARE RUN TO THEIR SITES ON A LIGHT RAILROAD AND LOWERED INTO POSITION BY A SMALL CRANE.

THE REINFORCEMENT OF POSTS AND STRUTS. THE TWO ARE BOUND TOGETHER AFTER BEING PLACED IN POSITION.

GROYNES OF REINFORCED CONCRETE TO CHECK COAST EROSION.

out at a little under $5 per foot run of groyne, which compares favorably with timber in first cost. The concrete, too, is more durable, and there is no danger from decay or sea worms, the activity of which on this coast is shown by the state of old timbers found on the foreshore. When the work was commenced, there was practically no sand to be found on the foreshore, which was of very rough exposed chalk; now at certain parts between the completed groynes, it is possible to walk from groyne to groyne on nothing but sand. Instead of scouring away the shore, the sea is now building it up; checked in its current by the groynes, it drops the sand which it carries and so gradually will raise its own barrier, which will keep it from the base of the cliffs.

OXIDATION-PROOF BRONZING.

SOME PRACTICAL SUGGESTIONS.

GILDING is undoubtedly the most superior and most durable, and at the same time unquestionably the most expensive form of metallic painting. A materially cheaper substitute process that, if skillfully carried out, closely resembles gilding, is bronzing. The effects to be obtained by coating with bronze have certainly proved to be meritorious. The only objection is, that in almost all these processes, the bronze effect lacks durability. As a rule, we may note that after a short time the bronzing loses its metallic color, and turns green, or even black. The cause of this unfortunate deterioration in connection with a bronze coating, lies in the premature oxidation of the bronze powder employed. The question therefore arises whether defects do not occur in the execution of the bronzing itself that contribute to the rapidity of oxidation. Mistakes, in other words, the obviation of which may prevent the too rapid and early oxidation of the bronze and insure a durable bronzing.

The occurrence of the oxidation process depends in this case, as is well known, on the access of oxygen to the bronze. The object, therefore, must be, in carrying out the bronzing process, to eliminate every factor likely to promote the action of the oxygen on the bronze. Where the bronze is applied like a paint, it is unquestionably first of all the bronze binding agent which, as far as oxidation is concerned, is open to suspicion. For it must be advanced as indisputable that a binding agent containing oxygen must give rise to an oxidation effect in the bronzing mixture, even before its application, which then speedily develops its objectionable character on the bronzed object. For this reason it is a great mistake, in selecting a binding agent, to base selection exclusively on the nature of the background. For this is responsible only for the adhesiveness of the bronze coating, whereas the resistance to oxidation must, in the choice of a binding agent, be considered as equally determinative. Only substances absolutely free from acid are, from this standpoint, permissible. As a rule, we may state that the aqueous or watery binding agents entail the least danger. Without further consideration, all thick-fluid binders should be rejected. On the other hand, the clearer and more colorless the binding agent, the less cause it gives for suspicion.

Now about the bronzes applied as color, i. e., the binding agent that forms the adhesive background for bronze dusted on in the form of powder. In this case, too, we cannot afford to leave the freedom from liability to oxidation altogether out of consideration on account of greater adhesiveness and special suitability in color shade. We must concede, without further question, that all attempts at effective metal coloring with the aid of the bronzing process will be labor in vain, where, at the same time, the most comprehensive precautions against the effects of oxidation are not simultaneously taken.

But even in a binding agent free from acid and an adhesive coating free from objection in this respect, dirty brushes and receptacles may easily furnish the grounds for the destructive acid effects. The chemical result in such a case is that in spite of all the care exercised in regard to binding agent or adhesive backing, the discoloring of the bronze coating by oxidation will be the ultimate outcome. This is a point that we are only too prone to consider as unimportant, and this, with inadequate carefulness and lack of conscientious painstaking, defeats from the beginning all hope of a non-oxidizable bronzing.

Freedom from acidity of the binding agent and adhesive coating, as well as chemical cleanliness of the apparatus used in bronzing, are the foundation of resistance to oxidation to be observed before the commencement of the bronzing process. There are further and no less important factors to be considered in the preparation and completion of the bronze coating itself. It must be remembered that the oxygen in the air, not only during the application of the bronze coating, but also after its completion, exercises its oxidizing effect on the bronze. It is necessary, therefore, so to arrange the bronzing process that this decomposing effect of the atmospheric oxygen is prevented as far as possible. And this must be effected in two ways.

The action of the atmospheric oxygen is, as may be supposed, the more energetic, i. e., the bronzing substance is the more accessible, even in its most minute particles, to the oxygen, the longer the applied bronze coating requires for drying and hardening. In order, therefore, during the drying, to prevent, as far as possible, the oxidizing effect of the atmosphere, it is necessary to expedite the hardening process, or in other words, the drying, in the application of the bronze coating. For this purpose it is essential, where liquid bronze paints are employed, to use the smallest possible quantity of binding material. Too liberal a supply of binding agent only serves to unnecessarily prolong the drying process, to the detriment of the oxidation-resisting capacity. That the drying may be accelerated, in the case of bronze paint, and also with adhesive coatings, by the addition of a siccative or drier, is already well known. Only they should not be regarded as indispensable and infallible, but only resorted to as an auxiliary in case of necessity and in moderation and with care.

Supposing the bronze coating to be completely dry, it is by no means entirely insured against the attacks of the atmospheric oxygen. Rather, the bronzing requires, to be quite safe, a protective coating that will effectively exclude the oxygen. This must be applied immediately on the drying of the bronze coating. In this connection we have first to remember that the protective coating, which partakes of the nature of a lacquer or varnish, must itself be absolutely free from any acid constituents. This precaution must be exercised for two reasons; in the first place, all varieties of lacquers and varnishes are themselves not always wholly free from every acid constituent. Experience has especially demonstrated that it is best that copal varnishes and shellac varnishes should not be employed in connection with bronze coatings. On the other hand, the damar varnishes are most free from acids. More serious, however, is the frequently undertaken color treatment by means of varnish colors. Certainly, the effort to enliven the bronze coloring cannot be condemned, off-hand, for all cases. But in every instance, in the selection of the varnish colors to be used for the protective coating, the resistance to oxidation of the bronzing should receive the first consideration.—Allgemeine Maler Zeitung.

THE ORIGIN OF SOME NAVAL AND MILITARY CUSTOMS.*

By M. V. CAMPBELL, Late Lieut. U.S.M.C.

THE many visitors aboard the battleships when the fleet arrives no doubt will be interested in some of the customs of the service. In a number of instances, they probably will be amused at the rigid manner in which they are adhered to. Some one has said that "habit is a cable; we weave a strand of it each day and in time it becomes unbreakable." The very day a midshipman enters the Naval Academy, he is taught the customs of the service, and in a short time they become ingrained in his nature. While to many of us his actions may seem perfunctory, in reality they have become second nature, and he would no more think of deviating from the course laid down by the navy regulations than he would of flying. Briefly, every naval service has certain well-defined, I might say mannerisms, whose origin in the majority of cases is of great antiquity.

One of the first that will be noticed is that of "saluting the quarterdeck." Many have the hazy idea that the national colors are its object and it is merely a naval fad. While to a certain extent it is a fad, it is one of a hoary antiquity, being a survival of the days when a crucifix was placed on the stern of a ship and was always saluted as a matter of course. When the crucifix was taken away, the old feeling still remained, and men continued to salute the place where it had been. The younger generation imitated their elders, and the salute became a habit and continues until this day.

At this point it would be well to take up the matter of salutes. It is a well-known fact that when addressing or being addressed, every junior must salute a superior, and it is commonly done by touching the visor of his cap. The evolution of the salute is most interesting. In feudal days when a knight arrived at a castle, he removed his helmet as he entered the hall (from which we get the custom of removing the hat in bowing or on entering a house), which was the same as saying he was confident of his host's good will and was not afraid of a surreptitious buffet from a sword or mace. To enter helmeted, or to delay baring your head within a reasonable time, meant that you were not exactly sure of your greeting and preferred to take no risks. Out of this came the military salute, which was tantamount to saying you would be willing to unhelm out of politeness's sake, but until you knew the will of your host you wished to be on the safe side.

Many service customs date back to the days when armor was worn. For instance, all authorities on social etiquette lay down the law that under no consideration may a man shake hands with a lady unless his own be bare. This was due to the fact that in those days the men wore iron gauntlets and to avoid doing real injury to the lady's hand the gauntlet was removed. The origin of offering the right hand in shaking hands comes from the same era. Formerly when a man met another and wished to show that his intentions were friendly, he offered his right or unarmed sword hand, which implied that his sword rested in its scabbard and was not going to leave it.

The firing of artillery salutes is also a relic of feudal days. When guns first came into use it was considered an act of extreme courtesy if you loaded all your guns with shotted rounds and fired them whenever a great personage approached your castle. The reason was the same as removing your helmet—you trusted your visitor by emptying all your guns before he came within range. This custom very rapidly went through many modifications. In the first place, rapid-fire guns were not in vogue in those days, and as firing and loading took considerable time, tradition says in several instances this friendly custom created havoc in the retinue of the approaching visitor, and the use of blank cartridges was adopted for obvious reasons. Naturally in a short time this courtesy was adopted by men-of-war.

To-day a man-of-war entering a foreign port fires a national salute of twenty-one guns. In the matter of saluting, an amusing story is told of the late Commodore Fife, a celebrated character in our old navy. Way back in the forties he entered a European port. Being very punctilious upon the matter of etiquette, as soon as his ship stuck her nose in the harbor, he ordered the national salute fired. Through the carelessness or what-not of the gunner's mate, twenty-two guns were fired. A little later the captain of the port came aboard and asked: "Why twenty-two guns?"

Commodore Fife threw out his chest and replied: "Twenty-one guns for the King of ——— and one for Joe Fife!"

Every one who has attended a naval or military funeral will remember that the last thing is a volley which is fired over the grave of the departed comrade, then the bugle call "taps" is sounded. This is another relic of the dark ages. It was believed that noise kept away the evil spirits, and for this reason a bell was sounded. When firearms were invented, volley firing was substituted for the bell, the belief being that the sound of battle was more efficacious for the soldier.

It will be noticed whenever a sailor comes ashore he has tied around his neck a black handkerchief. This custom is of more recent date. It serves to perpetuate the memory of England's greatest sailor—Lord Horatio Nelson. After Nelson's tragic death, the order was published that every sailor in the British navy should wear a black handkerchief, and as all the navies of the world are more or less imitative in the matter of dress, the black handkerchief became generally worn.

* Los Angeles Times.

According to the Electrical Engineer the scheme for the construction of a railway from Capetown to the top of Table Mountain has now assumed the definite stage, and alternative projects are to be made the bases of tenders. The proposals put forward are for the construction of a railway and hotel on the summit of the mountain, but no limitations are to be imposed on tendering firms as to the system which their engineers may advise should be adopted. The construction may be of the rack-and-pinion, funicular, or other approved type, but a concession is not to be granted in respect of the line for a longer period than twenty-five years, the municipality reserving the right to purchase on the expiration of that term.

THE QUEBEC BRIDGE DISASTER.

A SUMMARY OF THE FINDINGS OF THE COMMISSION OF INQUIRY APPOINTED BY THE CANADIAN GOVERNMENT.

REPORT OF THE COMMISSION.

AFTER five months of continuous labor on the part of the commissioners, the unanimous report of the Commission of Inquiry on the Quebec Bridge Disaster was presented to the Canadian Parliament on March 9. We present below an outline of the investigations made and a summary of the conclusions reached by the commission, as contained in the introduction to the report:

"In carrying out our instructions we have made the following investigations:

"(a) A study of the history of the Quebec Bridge and Railway Company, the evidence at our disposal being copies of the various public acts concerning it, the minutes of the directors' meetings, the reports of its officials, its annual reports, its correspondence and copies of the agreements and contracts that it has made.

"(b) A perusal of the entire correspondence on file in the offices of the Quebec Bridge Company, the Phœnix Bridge Company, and of Mr. Theodore Cooper.

"(c) A study of the working organizations of the Quebec Bridge and Railway Company, the Phœnix Bridge Company, and the Phœnix Iron Company. This involved the hearing of a number of witnesses under oath and the examination of the various documents produced by these witnesses on directions of the Commission and filed as exhibits.

"(d) A personal inspection of the furnaces and rolling mills by which most of the metal that was used in the bridge was produced. The testing equipment at each of the works was examined and the file of the record of tests made by the inspectors during production was gone over.

"(e) A study of the methods used in the fabrication, transportation, and erection of the bridge. This consisted of inspection of the shops of the Phœnix Iron Company, in which all the metal was fabricated, and an examination of the plans, records, correspondence, and photographs on file in the office of the Phœnix Bridge Company. The fabricated material for the north half of the bridge was also inspected and check measurements were taken to determine certain questions of workmanship.

"(f) A study of the errors in workmanship detected by the several inspectors during the progress of the work, the evidence available being the record books kept by the shop inspectors for the Phœnix Bridge Company and for the Quebec Bridge and Railway Company, the 'field corrections' sent by the Phœnix Bridge Company's resident engineer to the erection department of that company, and the weekly reports made by the inspector of erection for the Quebec Bridge Company to the consulting engineer.

"(g) An inquiry into the history of the erection of the bridge. This inquiry was made by obtaining direct evidence from witnesses under oath and by tracing out through records and correspondence the details of all the major difficulties that had occurred in the course of construction.

"(h) An endeavor to obtain from eye-witnesses of the disaster all the details concerning it. Some twenty-five witnesses were examined for this purpose.

"(i) An examination of the meteorological records of the day of the accident and for some time previous. The records of the observatory at Quebec and those kept by the Phœnix Bridge Company's staff were available for this purpose.

"(j) A personal examination of the fallen structure made at different times and occupying several days, together with such surveys, check measurements, and photographs as were considered necessary.

"(k) A study of the methods adopted in the design of the bridge. This study required an inspection of the drafting office of the Phœnix Bridge Company, and an examination of the mass of preliminary and final designs on file there. The sworn statements of all the senior engineers formed an important part of the inquiry.

"(l) A checking of the stress sheets prepared in the offices of the Phœnix Bridge Company by comparison with results obtained by Mr. C. C. Schneider, consulting engineer, who was employed subsequent to the disaster, by the Department of Railways and Canals, to report to it on the design of the bridge.

"(m) A comparison of the organization and specifications used for the Quebec Bridge with those used for existing great cantilever bridges on this continent.

"(n) A replotting of the records of tests made on full-sized compression members and a comparison of the design for the principal compression chords of the Quebec Bridge, with similar designs for other great cantilevers. In this connection special tests were made both by the Phœnix Bridge Company and by the Commission, the details of which are given.

"(o) A study of the theory of compression members, standard books, transactions of technical societies and professional journals being consulted. The purpose of this part of the inquiry was to determine how thoroughly the designers of the bridge availed themselves of the professional knowledge at their disposal."

In summing up the investigation, the report says:

"Your Commissioners find:

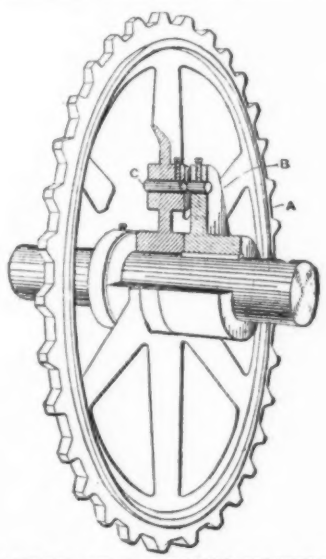
"(a) The collapse of the Quebec Bridge resulted from the failure of the lower chords in the anchor arm near the main pier. The failure of these chords was due to their defective design.

"(b) The stresses that caused the failure were not due to abnormal weather conditions or accident, but were such as might be expected in the regular course of erection.

"(c) The design of the chords that failed was made by Mr. P. L. Szlapka, the designing engineer of the Phœnix Bridge Company.

"(d) The design was examined and officially approved by Mr. Theodore Cooper, consulting engineer of the Quebec Bridge and Railway Company.

"(e) The failure cannot be attributed directly to any cause other than errors in judgment on the part of these two engineers.



EXAMPLE OF A DESIGN HAVING A BREAKABLE PIN AS SAFETY DEVICE.

"(f) These errors of judgment cannot be attributed either to lack of common professional knowledge, to neglect of duty, or to a desire to economize. The ability of the two engineers was tried in one of the most difficult professional problems of the day and proved to be insufficient.

"(g) We do not consider that the specifications for the work were satisfactory or sufficient, the unit stresses in particular being higher than any established by past practice. The specifications were accepted without protest by all interested.

"(h) A grave error was made in assuming the dead load of the calculations at too low a value and not afterward revising this assumption. This error was of sufficient magnitude to have required the condemnation of the bridge even if the details of the lower chords had been of sufficient strength because, if the bridge had been completed as designed, the actual stresses would have been considerably greater than those permitted by the specifications. This erroneous assumption was made by Mr. Szlapka and accepted by Mr. Cooper and tended to hasten the disaster.

"(i) We do not believe that the fall of the bridge could have been prevented by any action that might have been taken after August 27, 1907. Any effort to brace or take down the structure would have been impracticable owing to the manifest risk of human life involved.

"(j) The loss of life on August 29, 1907, might have been prevented by the exercise of better judgment on the part of those in responsible charge of the work for the Quebec Bridge and Railway Company and for the Phœnix Bridge Company.

"(k) The failure on the part of the Quebec Bridge and Railway Company to appoint an experienced bridge engineer to the position of chief engineer was a mistake. This resulted in a loose and inefficient supervision of all parts of the work on the part of the Quebec Bridge and Railway Company.

"(l) The work done by the Phœnix Bridge Company in making the detail drawings and in planning and carrying out the erection, and by the Phœnix Iron Company in fabricating the material was good and the steel used was of good quality. The serious defects were fundamental errors in design.

"(m) No one connected with the general designing fully appreciated the magnitude of the work nor the insufficiency of the data upon which they were depending. The special experimental studies and investigations that were required to confirm the judgment of the designers were not made.

"(n) The professional knowledge of the present day concerning the action of steel columns under load is not sufficient to enable engineers to economically design such structures as the Quebec Bridge. A bridge of the adopted span that will unquestionably be safe can be built, but in the present state of professional knowledge a considerably larger amount of metal would have to be used than might be required if our knowledge were more exact.

"(o) The professional record of Mr. Cooper was such that his selection for the authoritative position that he occupied was warranted, and the complete confidence that was placed in his judgment by the officials of the Dominion government, the Quebec Bridge and Railway Company, and the Phœnix Bridge Company, was deserved."

THE BREAKABLE PART AS A PREVENTION FOR OVERLOAD.

IN a contemporary we find reference made to a design of hub for a chain wheel used in connection with some kind of hoisting apparatus. The design is shown in the accompanying illustration. In order to prevent the overload, and consequent breaking of other parts of the machinery, a safety device is applied in the form of a pin, connecting the driving hub *B* with the hub of the gear *A* itself. As seen from the cut, the gear, instead of being keyed to the shaft, is loosely mounted, and the hub *B* is keyed to the shaft instead. This hub is connected to the chain wheel by pin *C*, which is necked, the extent of the reduction of the neck of the pin determining the amount of power which may be safely transmitted. If the apparatus is subjected to an unusual strain, the pin will break, leaving the wheel free, and thus preventing the breakage of parts which would cause serious accident.

This scheme of applying a breakable part in machinery to prevent overload and the breakage of more important portions, has been resorted to in several classes of work. It is, however, one that can hardly be recommended as an extremely happy one. In the case of a pin for transmitting the power, the temptation of the operator will always be, in case the pin should break, to replace it with one of stronger material, so as to prevent the annoyance due to frequent replacement. In the case in hand, there is, of course, an obvious temptation, if the pin should break, to replace it immediately with another pin without taking time to neck it down, in which case the new pin may have a power of resistance about double that of the one broken, and the original object of this safety device would be lost. The ideal safety device is one which does not break in the case of overload, but which is simply thrown out of action when the load becomes too heavy, and which can be moved back into position again by simply turning it like a lever. In such a case, there is no temptation for the operator to prevent the proper action of the safety device, and there is less risk that the device will be inoperative at the very time when its action is most required. In electrical work this principle has been realized and acted upon, and the old-fashioned fuses, which were inserted in circuits in order to prevent overload, are being replaced by circuit breakers. The fuses, in fact, correspond directly to the breakable pin, and circuit breakers have their direct counterpart in some kind of a lever arrangement in mechanical design, which would automatically be thrown out of engagement in case of too heavy load.—Machinery.

A NEW 16-SPINDLE DRILL.

SOMETHING NOVEL IN MACHINE TOOLS.

THE introduction of high-speed steel for drills has called for stronger drills to stand the increased feed and speeds. To meet this need the Crane Company, of Chicago, has introduced the novel 16-spindle drill shown in our illustrations. In order to avoid complicated mechanism, each spindle is driven by a separate motor which has sufficient power to handle the largest drill used in the machine—1⅝ inches in diameter. Fig. 2 is a side view showing one of the outer columns in the center. The motor *A* is mounted on the frame *B*, which rests on the base plate *C*, but is free to move in or out on this base to any desired position, and gives any bolt circle between 3⅛ and 36 inches.

It will be noted that each drilling unit, which includes the motor, base, gearing, drilling machine *D* and *F* and spindle is not fastened, but rests on the base plate *C*. The upward thrust is taken by the plate over the frame *D*. It was intended to magnetize the holding plates to hold the drilling unit in any position, but this has been found unnecessary in actual practice.

All adjustments of this machine, necessary to change for different sizes of work, are made without the use of wrenches, drifts, or any sort of tool. Only the fingers of the operator are necessary. Drills may be set all at the same level and time in a few seconds, simply by turning the adjusting nuts, which may be seen in the details of Fig. 3.

Each drill spindle is driven by a sleeve coupling which fits onto the shaft of the motor through a pair of special angle bevel gears and a universal joint. There is no feed attached to the drill spindles, the work being fed up to the drills from below.

The table upon which the work rests is capable of feeding from 2½ inches to 50 inches from the floor, and it is driven by a separate motor provided with changes of speed for the feed. There also is a quicker movement up or down for adjusting the table to the work.

The table is pivoted at its center, so that while a piece is being drilled upon one end, the other projects beyond the upright frames in order that another piece of the work may be made ready and swung into position under the drills as soon as the piece on the other end is finished.

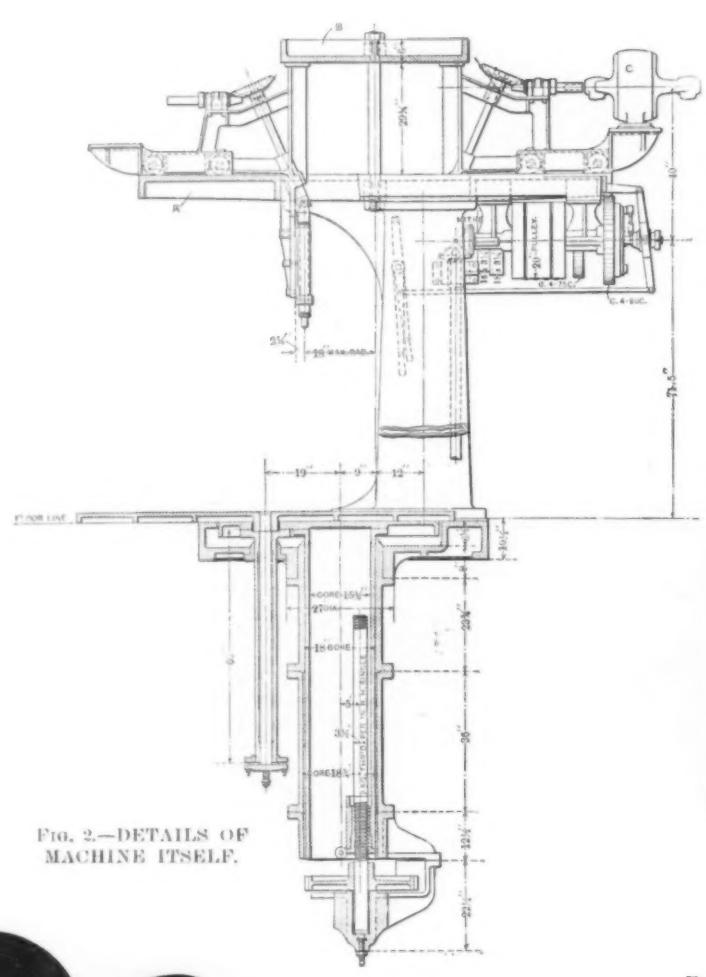


FIG. 2.—DETAILS OF MACHINE ITSELF.

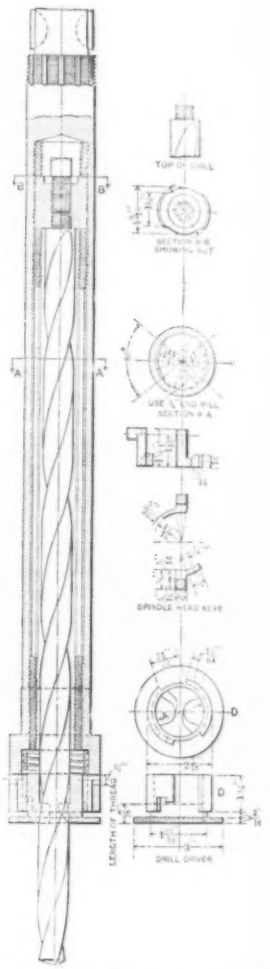


FIG. 3.—A DRILL AND HOW IT IS DRIVEN.

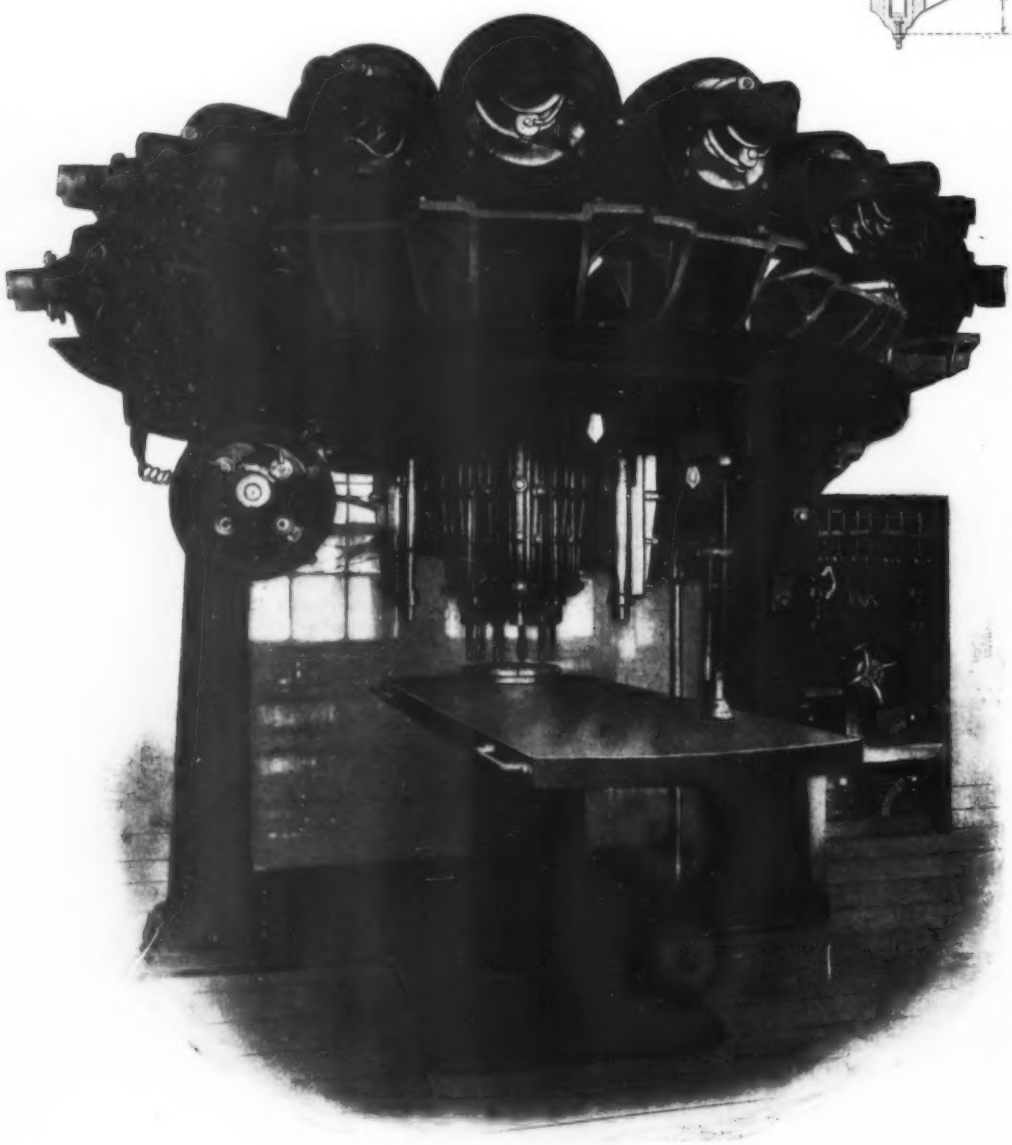


FIG. 1.—A NOVEL 16-SPINDLE DRILL.

The drills used are twist, specially made without a shank, and are 24 inches long when new. They may be used until there is only 2½ inches in the socket. The drill is held from turning by the holder at the bottom of the spindle, which is provided with lugs fitting into the flutes of the drill. The holder is inserted with the drill, a slight turn backward preventing it from falling out and bringing it against feathers in the spindle. Fig. 3 shows full details of this.

Any upward movement of the drill due to thrust is prevented by a threaded nut fastened adjustably to the top of the drill, this being turned so that the threads on the nut engage with the threads on the inside of the spindle. The nut at the top of the drill is ground, so that the drills may be kept the same height.

Spindles not needed may remain idle, so that power is used only for the number of drills required, whether that be one, two, or any number up to sixteen.

AIRSHIPS IN WAR.

MR. HUDSON MAXIM, who spoke at the annual banquet of the Aero Club of America in New York, contended that the use of airships in war does not hold forth any terrifying prospects. The dropping of dynamite from such vessels, he argued, might cause some superficial destruction, but it must penetrate and explode inside battleships and earthworks to do really great damage. Half a ton of that explosive dropped upon the four-inch deck of a battleship might kill some men, wreck part of the superstructure of the vessel, and dent the deck, but the destruction would not be extensive. Nor would the dropping of such a charge on coast fortifications cause serious damage, the action of dynamite being such that the blast, being unconfined, would rebound into the air in the form of an inverted cone, so that the effect in a horizontal plane would be small. The chief use of airships for military purposes, said Mr. Maxim, would be in scouting and spying upon the enemy's works. A simple calculation will show that the entire population of Greater New York, about four millions, could be packed together in a space not greater than half the

area of the Central Park. The mathematical relation of this space to the entire territory of the great city and a comparison of this with the area that could be covered by exploding shell in the case of a bombardment, or the most extravagant calculation of the danger zone created by the dropping of shells from a balloon, will furnish the factors for calculating the percentage of danger incurred by any individual in the case of an attack from ships and balloons by an invader who should disregard all of the humanities of war in his methods of assault. The individual risk would not be so great in that event as those the New Yorker incurs every day of his life from the ordinary street accidents, to which he gets so accustomed that he is scarcely aware of their existence.

A CONSTANT-LEVEL GAS METER.

HOW THE WATER LEVEL IS MAINTAINED.

BY G. CHALMARES.

THE accurate measurement of gas is a problem of great interest to the consumer but it is still more important to the purveyor who, as we shall see, is usually the party injured by defects in the meter. The essential organ of the ordinary gas meter is a bucket wheel partly immersed in water and turned by the buoyancy of the gas as it fills the buckets in succession. The revolutions of the wheel being registered by a train of mechanism and the capacity of the buckets being known, it is apparently a simple matter to calculate the quantity of gas that has flowed through the meter. But although the capacity of the buckets is fixed the quantity of gas that they can receive before they are driven upward and emptied depends on the level of the water in which the wheel turns. If this level rises the pressure of the gas in the bucket is increased and the bucket rises before it has received the proper quantity of gas, causing loss to the consumer. This contingency is easily met by an overflow pipe above which the water cannot rise unless the pipe is stopped.

On the other hand, if the level of the water falls the effective capacity of the bucket is increased and more gas is delivered than is recorded by the meter.

Unfortunately for the gas companies the evaporation caused by the stream of gas operates constantly to lower the water level in the meter. The loss of water has been found by numerous experiments to amount to nearly ½ ounce per 100 cubic feet of gas at the mean temperature of 60 deg. F.

Hence the makers of gas meters have been compelled to devise various methods of keeping the water level constant. The simplest device is the floating compensator illustrated by Fig. 2, No. 1. The engraving shows the back of the meter, which communicates with the front part containing the bucket wheel, so that the water is always at the same level in both compartments. The compensator *F* is a closed semi-cylindrical box which is free to turn about an axis placed at the middle of its straight side. If there is no water in the meter this straight side lies nearly but not exactly horizontal as the compensator is slightly weighted on one side. When the water is admitted the compensator turns until it reaches a position of equilibrium. It is evident that the weight and volume of the compensator may be so calculated that any tendency of the water level to fall below the prescribed height will be counteracted by the displacement of water caused by the sinking of the compensator. The exactness of the compensation, however, is destroyed if there is friction at the axis or if the weight of the compensator is increased by deposits of lime salts. It is necessary, furthermore, to make the meter inconveniently large. For these reasons this simple device has been superseded by more complex contrivances. The back of the Scholfield meter (Fig. 2, No. 2) contains three compartments. Two of these are in communication with the front compartment which contains the bucket wheel. The remaining compartment (on the right of the illustration) is an isolated reservoir in which the water stands at a lower level. The back end of the arbor of the bucket wheel carries a pinion which engages with a toothed wheel on the shaft of a rotary pumping machine consisting of the bent tube *S*. As this tube revolves its ends dip into the reservoir and scoop up a little water which is discharged, through a hole in the middle of the tube, into the communicating compartments of the meter. In this way water is continually added to replace the loss by evaporation, any excess flowing back into the reservoir through an overflow, the height of which determines the water level of the other compartments. Meters of this type are used chiefly in England.

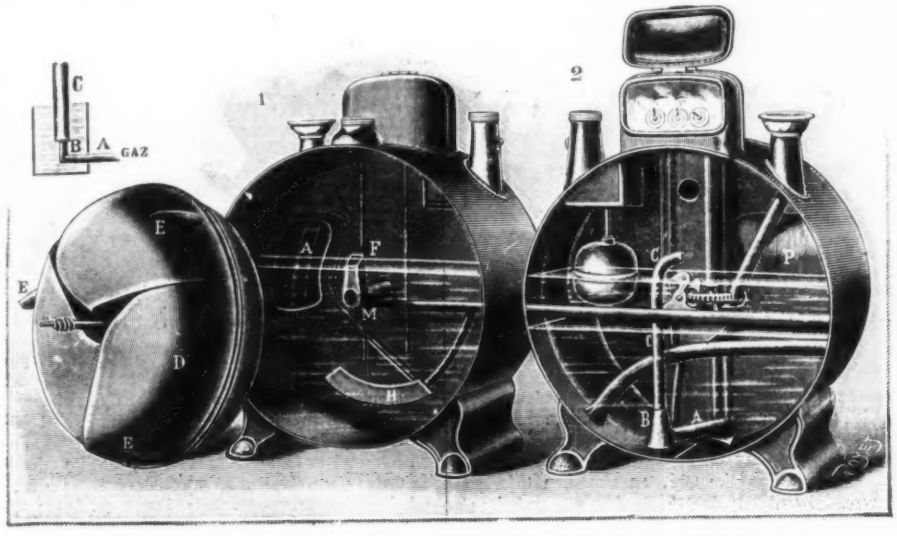


FIG. 1.—DUPOY'S CONSTANT-LEVEL GAS METER WITH INJECTOR.

1. The bucket wheel and its housing. 2. Front of apparatus, showing injector.

In France they have been superseded by the spoon meter (Fig. 2, No. 3), in which the bent tube is replaced by the spoon *C*, which is alternately dipped into the reservoir and emptied into the other compartments by the jointed levers *L*, driven by the shaft of the bucket wheel.

Both of these ingenious systems involve the introduction of mechanism which is driven by the bucket wheel and is liable to sudden derangement. M. Dupoy, a Paris manufacturer of gas meters, has invented a new device which contains no mechanism, but makes use of a sort of injector, the principle of which is illustrated by the small diagram at the left of Fig. 1. If the bottom of the vertical tube *C*, which is ¼ inch or 1/3 inch in diameter and open at both ends, is immersed in water and a small stream of gas is admitted through the tube *A B* the gas accumulates at *B* and forms a large bubble which suddenly rises through the tube *C* carrying the water with it. Before the next bubble has formed, the tube *C* has been refilled by water entering at the bottom, and so the process goes on indefinitely. Dupoy's duplex injection meter is illustrated in Fig. 1. The shaft of the bucket

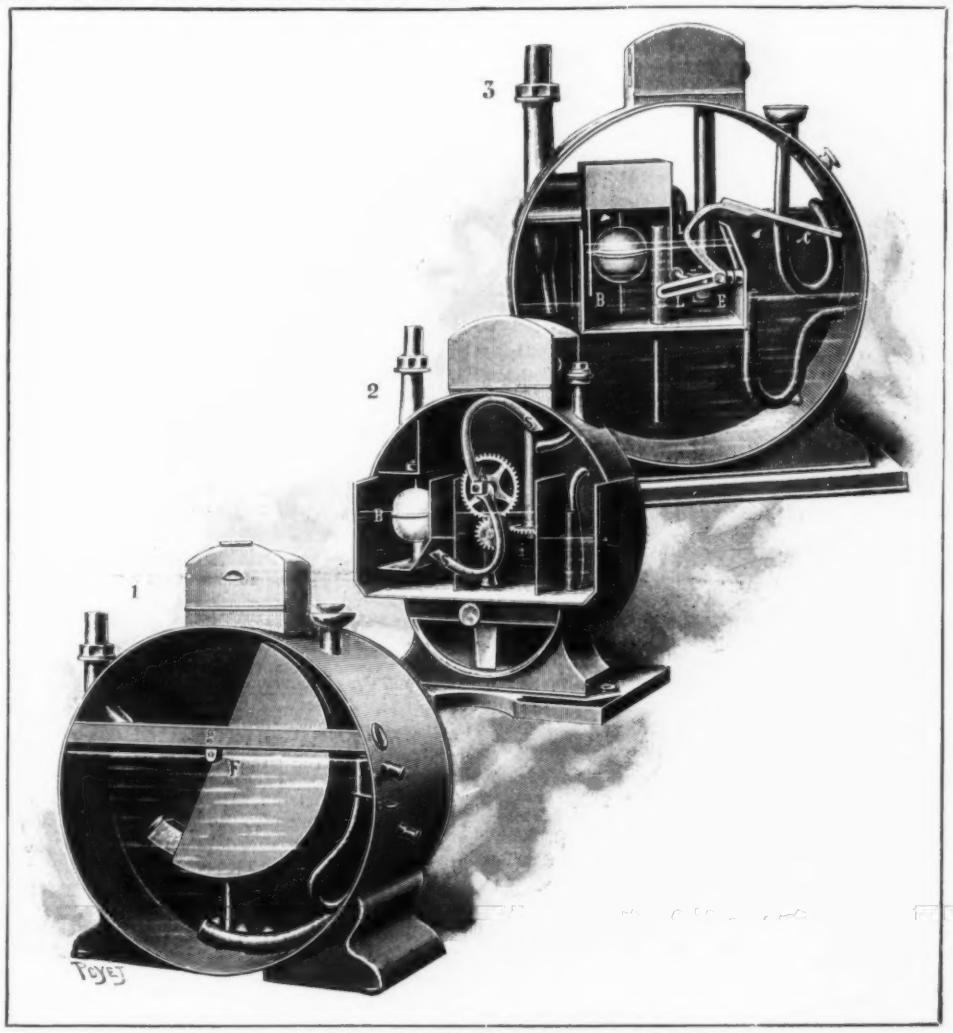


FIG. 2.—OTHER CONSTANT-LEVEL GAS METERS.

1. Floating compensator meter. 2. Scholfield meter. 3. Spoon meter.

wheel *D* (shown detached) turns in the bearing *M* and the gas is admitted to the three buckets of the wheel through the tube *F*. The function of the small exterior buckets *E* is to entrap a little gas at the top of their revolution and discharge it into the receiver *H*, whence it flows to a chamber communicating with the gas tube *A* of the injector. In the illustration of the front of the meter (Fig. 1, No. 2) *P* indicates this gas chamber, and *A*, *B*, and *C* denote the parts of the injector as in the small diagram. The bottom *B* of the vertical tube dips into the water reservoir, while the water is discharged from the top of the tube into the communicating compartments, one of which contains the bucket wheel. Each revolution of the wheel brings a little gas to the chamber *P*, and when the pressure in this chamber attains a certain value the injector begins to operate in the manner described. Thus water is continually supplied (unless the reservoir is allowed to run dry) to replace the loss by evaporation and the level is kept constant by overflow into the reservoir. There is no machinery to get out of order and no energy is taken from the bucket wheel.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

THE PHOTOGRAPHY OF COLOR.—I.*

A HISTORY OF PHOTOGRAPHIC COLOR RESEARCH AND ITS PRESENT STATUS.

BY CHAPMAN JONES, F.I.C., F.C.S., ETC.

As this problem has engaged the attention of innumerable workers for nearly a hundred years, and the best methods so far known are now carried out on a considerable scale, it is obviously impossible to deal with the subject with any approach to completeness within the compass of an article such as this. I propose, therefore, to consider the principles involved rather than the practical details, and to deal with the subject broadly rather than minutely.

The simplest idea and the most acceptable method of the photography of color is that in which the color of the object is reproduced as automatically and correctly as its shape, and shall be visible on ordinary inspection as the colors of a painting are. Such color photography has been eagerly sought for, but is as yet impossible; and if one is justified in judging of the future in the light of the past, it will remain impossible. There does not seem any line of work that can lead to such a result. From this point of view color photography as now practised is always a compromise.

The methods of both the past and the present naturally fall into two classes. The less important division includes methods in which a single homogeneous surface is employed, while in the larger division the surface is multiple or non-homogeneous. The first is generally an attempt to get as near as possible to the simple color photography described above, while the second is entirely indirect in that it does not aim at producing color at all, but only at automatically locating suitable dyes or inks. We will consider the direct method first.

Dr. T. J. Seebeck, of Jena, in the year 1810 or thereabout, while making some experiments as to the action of the solar spectrum on silver chloride, observed that the violet light of the spectrum produced a reddish brown substance sometimes inclining toward violet, that the blue light produced a blue substance, and the red a rose or lilac substance. If the silver salt had previously been exposed to light for a time, so as to darken it, there was a bleaching action where the red and yellow light fell upon it. It is hardly likely that he had in mind any photographic process whether in color or otherwise, as photography at that time was not a practical art. Eight years before this, Sir Humphry Davy had described at the Royal Institution the attempts of Thomas Wedgwood, which he had supplemented, to get a practical photographic method—a printing process as we should now call it—but their preparations were very lacking in sensitiveness, and no method of fixing them was known. Of those who were primarily concerned in working out practical photographic methods, the elder Niepce began his work in 1814, Daguerre in 1824, and Fox Talbot in 1833, and it was not until 1839 that their work culminated in serviceable processes.

Edmund Becquerel appears to have been the first to specifically attack the problem of the photography of color. It is stated that he began his investigations in 1838, though he did not publish any results of them until ten years later. Although the earlier date was just before the methods of Daguerre and Talbot were published, there is no doubt that there was a general knowledge in scientific circles that something of the kind would shortly be made known, and that this directed the attention of many investigators to the possibilities of photography. But long before 1848 other workers had made observations concerning the photography of color. Sir John Herschel had repeated Seebeck's experiment; Daguerre and Fox Talbot had both observed that in some of their photographs a red object produced a red color in the picture; and Robert Hunt had succeeded in obtaining colors on paper impregnated with various silver salts. Hunt put, for example, a prepared sheet under red, yellow, green, and blue glasses, and exposed the arrangement for a week to diffused light. The silver chloride "became red under the red glass, dirty yellow under the yellow glass, a dark green under the green, and a light olive under the blue." But with a sheet "differently prepared" he tells us he obtained "a very beautiful picture," in which the sky was crimson, stucco-fronted houses came out slaty blue, and the green fields of a brick-red tint.

Becquerel used silver plates and produced a layer of silver chloride on the surface of the metal, at first by the action of cupric chloride, but afterward by the electrolysis of dilute hydrochloric acid with the silver plate as the positive electrode. The plates were treated until the very thin layer of the accumulating chloride on their surfaces had passed through certain definite color-changes, and then washed, dried, and warmed. With these plates he reproduced, with a considerable measure of success, the colors of brightly dressed dolls and highly colored designs besides the solar and electric arc spectra.

There were many others who busied themselves with experiments of this character at this time and for many years afterward, making little variations and meeting with more or less success, sometimes propounding strange theories and endeavoring to justify them, and now and again expressing their hopes and almost their convictions that what they sought for was just coming within their reach. But their hopes were ill founded, for the work was purely empirical; they had no sound principles to guide them, and no real progress was ever made. Even the colors obtained were not permanent, and though some when considerable care was taken to preserve them lasted longer than others, the difficulty of "fixing" them, or rendering them even moderately stable, was never overcome. We shall shortly see something of the nature of the colors produced in these experiments.

If light waves are similar to the waves produced by disturbing the surface of water, as they are supposed to be, it follows that if a continuous series of waves is reflected back upon its original path, the waves traveling in opposite directions will interfere with each other. It is clear that as they move in opposite directions each wave will alternately coincide with and oppose a wave of the series that it is meeting, and that where they coincide their moving power on the particle concerned will be added, and that where they are opposed the particle can obey neither impulse, and therefore remains stationary. There is thus produced a series of "standing waves," for although their crests rise and fall or move to and fro at (practically) right angles to the path of the disturbance, they move in neither direction along the path. The alternate crests move in opposite directions, and between each and the next there is a stationary point. If these conditions are realized in light waves, the light will be quenched at those points where the movement of the particles (of the luminiferous ether) is prevented, and there will result a series of layers of light with intervals of darkness half a wave length apart.

Dr. W. Zenker, of Berlin, in 1868 published a small volume, "Lehrbuch der Photochromie (Photographie in natürlichen Farben)," in which he examined in detail the methods, theories, and results of the work that had been done up to then in connection with the reproduction of color. While satisfied that colored light will under certain conditions produce something that reflects the same, or very nearly the same, color as the incident light, he points out the insufficiency of the theories of the change that had been put forward. The color of the incident light, though reproduced more or less in all cases, is especially noticeable when silver plates are used, as in the method of Becquerel. He then explains the nature of standing waves, and advances this as an explanation of the phenomenon. The silver chloride, especially if violet (that is, slightly reduced), is so affected by the light that metallic silver is produced in layers, with intervals of no chemical change which correspond to the parts where the light is quenched by interference. He supposed metallic silver to be produced because it is necessary for the reproduction of the color that the product of the change shall be a good reflector. As to why reflecting laminæ of this kind should reflect only or chiefly light of the same wave length (or color) as the light which produced the laminæ when they are illuminated by white light, he explains that light of a greater or less wave length than that of the original incident ray will be out of harmony with the reflecting laminæ, so that the reflections from the various laminæ will be in dissimilar phases, and the resulting interference will cause this light to be more or less extinguished. But that part of the white light that corresponds in wave length to the original ray will be reflected at each lamina in such a manner that the difference in progression will always be equal to exactly a whole wave length, and therefore the light reflected from each surface will reinforce that from every other. He considered that this explanation followed from the wave theory of light, and required only one hypothesis, namely, that the product of the light action should reflect light strongly.

Although Zenker was not entirely correct and his theory did not pass unchallenged, his work eventually proved to be of great importance. Still, it was hardly appreciated at the time, and was apparently soon forgotten. Perhaps the method of its publication militated against its being widely known.

Lord Rayleigh in 1887, and Prof. Otto Wiener of Aachen a few years later, both independently and without knowledge of Zenker's work, suggested that the production of standing waves might account for at least some of the results of the early color photographs. But Wiener went a great deal further than this, and in 1895 published the results of an exhaustive examination of these methods, including the testing of pictures produced by them, to determine whether the colors were due to pigmentary matter or interference or both. He used a right-angled prism of dense glass with its three faces polished, placing the hypotenuse surface in contact with the spectrum photograph to be tested, with a liquid of high refractivity (gasoline) between to exclude air, so that the refracting edge of the prism crossed the color boundary. The color was then viewed, with certain precautions, so that part of it was seen directly and part through the prism. With a pigmentary color both parts remained of the same tint, but a color due to interference was changed by the presence of the prism, so that, for example, yellow appeared bluish green. Weiner prepared some examples of Seebeck's method (precipitated silver chloride darkened by exposure to white light and then exposed to the spectrum), and found the red a rose-red, the blue grayish, and the green and yellow very poorly represented, if at all. He found these colors to be pigmentary. A modification, due originally to Poitevin, but with slight improvements, was investigated. Silver chloride precipitated in paper was exposed to daylight in a solution of stannous chloride until darkened. It was then immersed in a solution containing potassium bichromate and cupric sulphate and exposed slightly moist. This reproduces all the colors more or less, but with a tendency toward a yellowish brown tint. These colors also are pigmentary. The colors produced by Becquerel's process, in which a silver plate has its surface converted into chloride by the electrolytic method, were found to be chiefly interference colors due to the action of standing waves, but there was pigmentary matter also present.

The color obtained in these older processes being due entirely to pigmentary matter, except when a metal plate was used, the natural question is, What is the character of the pigmentary substance? Wiener found that silver subchloride was sensitive to all the colors of the spectrum as silver chloride that has been exposed to light is, and as these two substances are alike in other properties, there seems little doubt that silver subchloride is the color-sensitive substance in these processes. Why it should be changed by colored light into a substance that has some approach to the color of the light that falls upon it is a problem still unsolved. But it seems exceedingly unlikely that any useful method of color photography will be realized on this line of work, because the colors at their best are only approximately similar to the color of the light that produces them; they cannot be fixed

* Abstracted from Science Progress.

because the pigmentary matter is decomposed by solvents of silver chloride; the subchloride does not bleach to white in white light, nor is it itself black—two conditions that must be fulfilled in a material that is to reproduce colors by the direct action of light. Wiener suggested as the ideal material a black mixture of three differently colored substances which are bleached to white by white light, and are sensitive in proportion to their absorption. In the next section the practical realization of this principle will be described.

We have already seen that "standing waves" were predicted as a necessary result of the undulatory nature of light, and it appears that several physicists sought to obtain experimental evidence of their existence, but it was not until 1891 that Prof. Gabriel Lippmann of Paris was successful. If these standing waves could be produced in a photographic film, it was argued that deposits of silver should be obtained starting where the amplitude of vibration is greatest, with no deposit at the nodes, and that these layers would reproduce the colors that originated them when they were illuminated with white light and viewed under suitable conditions. This, therefore, would constitute a method of color photography. It is obvious that for success the film used must be sensitive to all colors, it must have a good reflecting surface to send back the incident light, it must be transparent so that the reflected light may be as nearly as possible of its original intensity and that there may be a negligible amount of scattered light in it, and the sensitive material must be grainless, or very nearly so, for the layers of silver to be produced would be distant from each other, center to center, a dimension equal to only half a wave length of the light producing them. Lippmann solved the problem by coating glass with a suitable emulsion, and exposing it in a dark slide constructed to hold mercury. The glass side of the plate was turned to the light, and the sensitive film was backed up by the mercury which formed the reflecting surface. The evidence of his success lay in the facts that there was an obvious absence of pigmentary matter, the deposit being only gray silver, but that the colors of the original were reproduced as theory indicated by proper illumination and inspection, and that the colors changed by treating the film in any way that would alter the distance between the layers of silver, as, for example, by breathing on the plate and so slightly expanding the film. Perhaps the chief difficulty of this method is in insuring that when finished the film shall be in exactly the same condition as during the exposure, or at least that the distances between the silver deposits in the finished plate shall exactly correspond with the distances between the nodes of the standing waves of the incident light. The chief drawback to the results is that they must be illuminated and viewed at suitable angles. Many workers have improved the process in details.

It still remained to actually demonstrate the existence of the laminæ of silver in the film. Dr. R. Neuhauss, Mr. E. Senior, and others afterward, cut transverse sections of Lippmann films and obtained distinct proof of the presence of the laminæ, but by far the most complete and successful investigation of these films has been published quite recently by Prof. S. R. Cajal of Madrid. As the resolution of the laminæ requires an objective of a numerical aperture equal to or greater than the greatest available, Cajal swelled his sections in water and so obtained excellent definition. He has photographed sections of all kinds, and analyzed the effects by such methods as rubbing away the surface to distinguish between the effects of the superficial and the underlying parts. He confirms Zenker's theory exactly, except, perhaps, with regard to white. This he found was not due to the production and mixing of all colors or even complementary colors, but to simple reflection from a superficial deposit of silver; and in tinted whites or light colors he also found this superficial layer, but here it is partly transparent, and the interference colors produced by the laminæ below show through it.

(To be continued.)

BENARDOS SYSTEM OF ELECTRIC WELDING.

A SIMPLE PROCESS.

BY C. B. AUEL.

In the Benardos process an arc is drawn directly between the metal to be welded, which forms one terminal of an electric circuit, and a carbon electrode, which forms the other terminal.

It is the purpose to describe here in detail this process and its application in connection with steel castings, pipes and plates, though it has a considerably wider rage of usefulness.

Apparatus.—The outfit required for the welding of steel castings includes a direct-current source of supply, a rheostat, a carbon electrode and fire-clay or carbon blocks for molding purposes. An inclosure should be provided in which to carry on operations, for the glare from the arc is very intense and would seriously interfere with any other work in the immediate vicinity. The operator should have all parts of his body well covered (the clothing is quite sufficient), as even a few minutes' exposure to the rays will produce an irritating effect like sunburn upon the skin, resulting in a reddening and subsequent peeling of it with, however, no more serious consequences. For the head a canvas hood is generally used, being fitted with a small window of colored glass, through which the welding operation is watched without risk of injury to the eyes. The hands are usually protected by buckskin gloves provided with gauntlets to cover the wrists.

Current may be obtained from a 100 to 125-volt supply circuit. Assuming, however, that there will be sufficient welding to keep at least one man steadily employed, and taking into account first cost, subsequent maintenance, continuity of operation, simplicity and non-interference with other portions of the electrical plant, an independently-driven dynamo is perhaps to be preferred. It is of the utmost importance that the supply be of ample capacity, for more failures may be traced to an inadequate supply than to any other one cause. The dynamo should, therefore, be of about 75 to 100-kilowatt capacity at 100 to 125 volts, shunt or compound-wound, belt-driven or direct-connected; if the latter, a flexible coupling must be used, otherwise armature burn-outs are likely to be of frequent occurrence. With the dynamo should be provided a small switchboard having mounted on it the necessary instruments, voltmeter, ammeter, circuit breaker, field rheostat, and switch. If the dynamo is driven by a motor instead of by an engine, one or two additional instruments will be required for the control of the motor.

A very satisfactory rheostat is easily constructed by using two watertight barrels placed side by side. The positive cable of the circuit is carried from the dynamo to the switchboard and from the switchboard to the water rheostat. At the rheostat this cable divides into two smaller ones, these being fastened to separate triangular steel plates not less than ¼ inch thick, suspended above the barrels by means of pulleys and counterweights, so that the plates may be readily lowered into or withdrawn from the barrels as occasion requires the adjusting of the water resistance. Similar cables are run down the inside of each barrel and one end likewise fastened to a heavy plate of steel, which lies on the bottom. The other end of each of these cables is attached to the casting to be welded or the cables may be fastened to a metal table and the casting simply laid upon it, always provided good contact is made. The negative cable of the circuit is carried from the dynamo to the switchboard and from the switchboard to the vicinity of the casting to be welded, where it is provided with a metal terminal and clamp, into whch the carbon electrode is tightly fitted. In order to manipulate the carbon electrode during welding, the negative terminal is held in a wood insulating handle, to which is attached a shield of asbestos or other fireproof insulating material.

The selection of the proper carbon requires some care, and while almost any kind may be used, such will not give the best results. Experience seems to indicate as best for heavy work, a hard, solid (not cored) carbon of 1 or 1½ inches in diameter, 6 to 12 inches in length, and one that, as it wears away, leaves a round stub end and not a long pencil point. For lighter work, a carbon of smaller diameter will suffice.

In the general repair of steel castings, iron rod of about ⅜-inch diameter is used for filling (Norway iron is preferable), although small pellets from scrap boiler plates or steel castings may also be used, the choice between the rod and the pellets depending, to a certain extent, upon whether the weld is to be small or large.

Method of Making a Weld.—As before mentioned, the positive terminal of the circuit may be clamped directly to the casting to be welded, or it may simply be laid upon a metal table and the terminal clamped to the latter. The positive terminal is thus connected instead of the negative terminal so as to direct the flow of current from the casting to the carbon electrode, and in this way prevent carbon, when the electrode is vaporized, from entering the weld. The steel plates of the water rheostat are lowered into the barrels which have been previously filled with water, the circuit breaker and the switch closed, when the actual welding is ready to be undertaken.

The operator places himself directly in front of the casting, holding the negative terminal with its carbon electrode in one hand by means of the wood insulating handle, and having within reach of the other hand several pieces of iron rod. He then pulls the canvas cap well down over his head, touches the carbon to the casting, thereby closing the circuit and thus producing an arc. As soon as the arc is sprung, the carbon is withdrawn to a distance of 2 inches or more (too short an arc will tend to produce a hard weld), and the arc allowed to play upon the casting until the metal commences to boil. It is advisable not to concentrate the arc on any one spot, but to give it a circular movement so as to heat the casting very thoroughly within the immediate vicinity of the proposed weld. This will tend to prevent too rapid cooling of the metal with its consequent chilling and hardening effect. The end of one of the iron rods is now placed directly in the midst of the boiling metal, where it gradually melts and mixes with it, the arc meanwhile being continued. As the rod melts away, it is fed into the weld and this process is continued with one or more additional pieces of rod until the weld has been completed. The surface of the weld may be hammered as it cools off to produce a closer grain or so as to make it conform to some particular shape.

When pellets are used instead of the iron rod, they are placed in the weld or cavity, a few at a time, and the arc applied, more pellets being added as the first batch is melted.

Should the part of the casting to be welded present a dirty appearance or contain slag, it should first be cleaned by means of a chisel or by tilting the casting so as to allow the dirt or slag to drop off as fast as it melts when the arc is applied. After cleaning in this manner the casting is tilted back and the welding then proceeded with.

If possible, the weld should be made with one continuous application of the arc, as oxide of iron (scale) will form with each cooling and if not removed will assist in producing a very hard weld, that is, one not easily machined. Where, however, it is not possible to make the weld with one application of the arc, the scale should be brushed off by means of a stiff wire brush. Hammering the weld after cooling will also very materially assist in this cleaning.

When, instead of a cavity to be filled, it is necessary to build up a lug or to weld a piece to the casting, fire-clay or carbon blocks may be used for the purpose of confining the molten metal within certain desired limits or of having it assume a definite shape.

When the work is properly done, welds made by this method will give an average tensile strength equal to 70 or more per cent of the original stock.

It would be exceedingly difficult, if not impossible, to set forth in exact terms the relations existing between current, size of weld, time required for weld, etc., on account of the different variables which enter in, but the following data, obtained in welding a lug 1¼ inches in diameter and 2 inches thick to a casting, are approximately correct and will enable a rough idea to be formed of the magnitude of the several items involved:

Time for welding, 56 secs.; amperes, 600; volts across rheostat, 42; volts across arc, including carbon, 58; total line volts, 100; size of carbon; 1½ inches diameter by 6 inches.

Besides the welding of steel castings, the Benardos process may be advantageously employed in the removal of surplus metal, including sink heads, in the boring of large holes in castings or plates, in the welding of flanges, elbows and couplings to pipes, and in a variety of other ways.

The Benardos process gives thoroughly satisfactory results commercially; and is one which can easily be learned by any workman of average ability, after a few weeks' practice. The welds first made will generally be harder to machine than the other portions of the casting, but increasing familiarity with the process will reduce the number of such hard welds to a minimum.—Electric Journal.

FARMING THE KANGAROO.

A NOVEL EXPERIMENT WHICH HAS PROVED SUCCESSFUL IN ENGLAND.

BY HAROLD J. SHEPSTONE.

IT would certainly seem, provided the conditions are favorable, that there is scarcely an animal that man cannot successfully propagate. This is evidenced by the quaint animal farms which have sprung into existence during the last few years. After his success in establishing ostrich farms on the American continent, Mr. Edwin Cawston founded a similar institution in the South of France. He is now trying ostrich farming in England, and as an experiment he is keeping twenty birds on a small farm near London. Then at Hot Springs, Ark., we have a successful alligator farm run by Mr. H. J. Campbell. Until very recently a German count ran a zebra ranch in German East Africa. Although it has been given up, it was clearly demonstrated that the striped African horse could be bred and reared in captivity.

The latest animal to be reared by man is the kangaroo. The first kangaroo farm has now been established at Bath, England. The founders are two Englishmen, W. H. Payne and Jack Wallace, who have earned fame as collectors of Australian animals and birds. The farm has been in existence some twelve months, so may be said to have passed the experimental stage, and its success is an additional proof that provided the farmer is well acquainted with the habits of the creature he wishes to rear, and provides favorable conditions, there is no reason at all why his efforts should not be crowned with success.

The farm covers about four acres of ground, and is situated on a high hill overlooking the city. It is entirely surrounded by a high wall. This precaution is necessary, when the jumping abilities of the kangaroo are remembered. When the writer visited the establishment, between fifty and sixty kangaroos and wallabies were to be seen there, as well as a large number of Australian birds. The kangaroos, with hardly an exception, belong to the rarer species, and for that reason the experiment of rearing them is worthy of attention.

There were a number of antilopine kangaroos, undoubtedly the finest of all the marsupials. This animal is only found in the East and West Kimberley districts and the Northern Territory, the least explored parts of the whole of the Australian continent. The male has a beautiful rufus-red coat of fine long hair, which is parted all down the center of the back. It grows to the size of the great gray kangaroo, and when standing erect has a noble appearance. The female differs somewhat in color from the male; her coat is of a silvery fawn, with dark pencilings on the mane. The underpart of the body is white. As their name implies, they somewhat resemble an antelope in the shape of the head. They have very prominent ears, which are pricked up immediately they hear any strange sound.

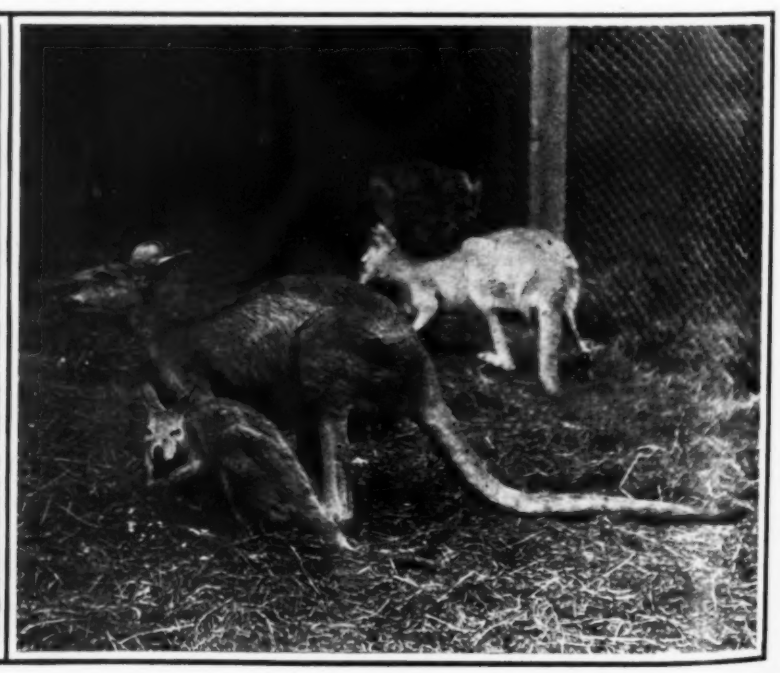
There are a number of this particular species at the farm, including one with young. The baby is now four months old, and it is the first antilopine born in captivity. The antilopines are remarkably tame and gentle. A pair of this species cost $375. There are only three zoological gardens in Europe that possess specimens of this interesting creature. Other rare species of kangaroos seen at this establishment include the Isabeline kangaroo, Woodward's kangaroo, Parry's kangaroo, and the silver kangaroo. Messrs. Payne and Wallace were the first to discover the last-named species. The idea that all kangaroos are alike is quickly dispelled after an inspection of the animals at this farm. There is as much difference between certain varieties as there is between a racehorse and a carthorse. As to price, they vary from as low as $50 a pair to as much as $375 a pair.

The collection of wallabies seen at the institution is a very fine one. It includes several specimens of the agile wallaby, the largest of the wallabies, and, like the antilopine, remarkable for its tameness. Its coat is a yellowish brown, and is short and rather coarse, the color graduating to white on the under parts of the body. It has a much longer tail than the other wallabies and is very fast in its movements. They are very docile, and when feeding time comes along, they have only to see the pan of corn, to come hopping along and jumping up to get at it. The writer was also pointed out a full-grown nail-tail wallaby, a lively little creature not much larger than a good-sized jack rabbit. It is so called because of the hard nail which nature has provided for it at the end of an appendage over two feet in length.

All the animals seen at the farm come from Northwest Australia. Mr. Payne is at present looking after the establishment in England, while his partner, Mr. Wallace, makes annual trips into the wilds of Australia, collecting this curious merchandise. It is Mr. Wallace's boast that he once never saw civilization for seventeen years. They are not only famous trappers, but keen naturalists. Their wanderings in savage Australian districts cover a period of more than thirty years. For a long time they used to bring their "catches" down to Sydney, and dispose of them there to European dealers. They then conceived the idea of bringing them to Europe, but doing only a wholesale business. They have now established a farm of their own in England, so as to deal direct with private purchasers.

These intrepid hunters employ two methods in capturing the wild kangaroo. One is by surrounding a water hole with wire netting, leaving an opening with a trap door for the creature to enter. Once inside, the kangaroo releases the drop and is caught. The next procedure is to catch him and place him in a sack. This is not found so difficult as may be imagined. In endeavoring to escape, the animal rushes at the wire netting. This is the hunter's opportunity, for by turning its back to him, the kangaroo lays open its most vulnerable point of attack—its tail. Rushing in, the hunter seizes the animal by its caudal appendage before it can recover itself, and lifts the creature completely off its hind legs. Held in this position a kangaroo can do little harm. A large sack is then placed on the ground, the mouth is held open, and into it the animal is allowed to walk on its fore paws, when it is conveyed to the camp. The other method of catching kangaroos is by hunting them with dogs and natives. The dogs drive the animals to the trees and hold them

A TAME WALLABY HOLDING A PIECE OF BREAD IN ITS FORKPAW. THIS SPECIES OF WALLABY IS THE MOST GRACEFUL OF THE KANGAROO TRIBE.



DIFFERENT SPECIES VARY WIDELY IN SIZE. A SMALL FULL-GROWN WALLABY AND A LARGE HALF-GROWN KANGAROO.

FARMING THE KANGAROO.

there until the natives arrive, who wait their opportunity to seize the creatures by the tail.

The great aim of the hunters on these expeditions is to secure the young ones. For this reason a number of special bags are taken along with the party, as well as some tame goats. When a baby kangaroo is secured, it is at once popped into a bag and the latter

A GROUP OF ANTILOPINE KANGAROOS IN THEIR PADDOCK.

suspended from the wagon. Native women feed the animal every two hours with goat's milk. When a number have been secured, they are carried to camp. Here the bags are suspended from trees, and the animals kept in them until they reach the age of five or six months, about the period they remain in their parents' pouches in the ordinary way. It has been found that kangaroos reared in this way become exceedingly tame.

The proprietors of the farm find a good market for their stock, particularly if the animals are at all docile. On many of the large estates in Great Britain kangaroos now roam, and in one or two instances they have even displaced deer. Their needs are small, all they require is a good piece of grass to get about on. Should the grass become poor, crushed maize and a little hay have been found ideal substitutes. In the summer weather they require no shelter whatever, preferring to sleep out in the open, but during the winter it is certainly advisable to furnish a house or shed into which they can retire when the weather is chilly.

RESUSCITATION OF ELECTROCUTED ANIMALS.

SOME time ago M. Leduc, a French scientist, successfully applied the intermittent electric current of low potential and constant direction in producing total or partial anæsthesia. Special apparatus was devised, by means of which electric narcosis can be easily obtained in the ordinary medical practice. Miss L. Robinovitch, M.D., of New York, has made a special study of the physiological action of the "Leduc currents" on the organism. Often she produces local electric anæsthesia in her surgical operations. Local anæsthesia of the fore-arm is easily obtained with 25 volts tension, one of the electrodes being applied to the inner elbow and the other to the wrist. The phenomenon of "electrical sleep," produced by electrical anæsthesia, is particularly interesting. Leduc has had the courage to subject himself repeatedly to this experiment. He has vividly described all his emotions: the loss of all his faculties and the painful impression produced by the utter impossibility of communicating with the experimenters, whose conversation he hears as if in a dream. Miss Rabinovitch has studied this phenomenon in a large number of animals, especially rabbits. She recommends the gradual increase of the current in order to prevent accidental troubles. As soon as the circuit is closed the animal shows signs of uneasiness, and with increase of current tries to escape without seeming to suffer. After a few light convulsions it falls on the side nearest to the cathode. After that the animal remains quite calm, closes his eyes, and seems to sleep. Respiration and pulsations of the heart are quite regular. For a current of 1 milliampere the tension is 5 to 6 volts. This state of electrical sleep may last for hours. As soon as the current is interrupted, the animal jumps to his feet, and not only does not feel any uneasiness, but shows every symptom of comfort, which is quite in accordance with Leduc's own experience.

On the other hand, if we send through the animal's body during a few seconds a current of a relatively high tension, say 55 volts, and then suddenly break the circuit, we observe very curious phenomena, similar to those in cases of epilepsy. Thus a few seconds after the circuit has been broken, the rabbit has rather violent convulsions, froths at the mouth, grits its teeth, and from time to time groans faintly. Then begins a state of coma, which lasts from a few minutes to half an hour. This experimental epilepsy is perfectly similar to real (pathological) epilepsy. The respiration and the functions of the heart are not inconvenienced by such a current, whose action seems to produce solely a superficial alteration of the nervous system, leading to a pseudo-epileptic crisis.

Now, a current having a tension from 12 to 15 volts, and acting on a rabbit from half a minute to a minute, gives quite different results. Real electrocution is produced. It is no longer sufficient merely to interrupt the current in order to re-establish the normal state. On the contrary, the heart's pulsations and respiration stop entirely, and without the intervention of the experimenter death would be inevitable.

Miss Rabinovitch has ascertained that giving to the animal intermittent electrical impulses in the same rhythm as respiration, we first produce artificial respiration, which generally soon becomes natural, and leads to complete resuscitation of the animal.

The experiments of Miss Rabinovitch illuminate the mysteries of death by electrocution. During a series of experiments on electrocution, the heart has continued to beat after the death of the animal, even after the thorax had been opened and the heart removed. In a special case the heart has beaten for half an hour after the autopsy.

In many cases it is possible to revivify electrocuted animals with the aid of Leduc's currents by the application of a current of the same voltage, provided this is done a short time after the interruption of the current. Miss Rabinovitch has also used voltages differing from the electrocuting potential.

Concerning the possibility of a practical utilization of these results, we may first of all affirm that the process may be used with persons having accidentally touched an electric wire with a tension up to 2,000 volts. If artificial electrical respiration is started without delay, the patient may be saved. Instead of the special interrupter of Leduc, a simple mercury interrupter can be used. The method is particularly easy with direct current. An alternating current must first be transformed into direct current.

Another very important application of the method of Miss Rabinovitch is the resuscitation of patients who have succumbed to chloroform or ether.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Revue générale des Sciences pures et appliqués.

THE LIME AND THE LEMON.

THE lemon is a deservedly popular fruit and serves as the foundation of that excellent beverage known as lemon squash, which, perhaps, is the best example of an absolutely non-alcoholic drink. The lime is not so well known, although from the point of view of flavor it is regarded by many as being even superior to the lemon. In view of the fact that there is now a good and abundant supply of limes to this country it is interesting to contrast the analysis of this fruit with that of the lemon. According to an analysis which we have recently made it would appear that the lime, although smaller than the lemon, yields weight for weight a good deal more juice. Thus the average amount of juice expressed from a lemon was 37.50 per cent of its weight, whereas the lime gave 59 per cent. Moreover, the lime gives more citric acid but less sugar, as the following analyses show:

	Juice of Lemon. Per cent.	Juice of Lime. Per cent.
Total solid matters	8.80	8.64
Sugar	2.30	0.70
Citric acid	4.57	5.60
Mineral matter	0.35	0.35
Potash	0.15	0.12
Phosphoric acid (soluble)	0.010	0.685

The lime therefore yields a "drier" juice and contains a third of the quantity of sugar present in the lemon. The antiscorbutic properties of lime juice may be regarded as more marked than those possessed by the juice of the lemon. While the alkaline salts amount to practically the same in both fruits, yet the phosphoric acid is greater in the lime than in the lemon. It is probably owing to the richness in alkaline salts that the use of lemon juice, as well as other fruit juices, is helpful in some diseases of the skin and in preventing eczema. The juice of the lime is equally valuable in this respect if, indeed, in regard to some dietetic points it is not superior. To those who are asked "to think imperially" there is another point about the lime which may appeal to them: it comes from British colonies and not from foreign countries. Fiscal reasons apart, the lime is an excellent and wholesome fruit and it seems a pity that we do not hear as frequently of a "lime squash" as we do of a "lemon squash."—Lancet.

KANGAROOS RESTING. THE ANIMAL STANDING UPRIGHT IS THE MALE.

FARMING THE KANGAROO.

ECLIPSES OF THE SUN AND MOON.*

HOW THEY ARE CALCULATED.

BY JACOB B. BROWN.

THE calculation of eclipses is a difficult and recondite matter which the present article has no intention of attacking. From the known intricacy of the calculations it is generally supposed, by those who have not much occasion to think about it, that the physical explanation of an eclipse is in like manner involved and difficult. The contrary is the fact, and an attempt will be made to show as much.

When the earth and the sun are both in the plane of the ecliptic, the opaque and spherical earth intercepts the rays of the sun and casts a conical shadow—conical because the sun is so much larger than the earth.

There may be those who do not know, or, at all events, have not reflected that the plane of the ecliptic means neither more nor less than the plane where eclipses take place. It is obvious that in order that one body be eclipsed by another for a third, the three must be in the same straight line, or nearly so. If two of the bodies be in a given plane, the third must be in the same plane. The moon can eclipse the sun when she is "in her nodes" or passing through the plane of the ecliptic, and at no other time; for the sun and the earth are there already as matter of course. There can be a transit of Venus when Venus is in her nodes, or crosses the plane of the ecliptic, and only then; for the transit is a kind of eclipse. And the conical shadow cast by the earth is always on the surface of the ecliptic plane, and at intervals exactly calculable, catches and more or less completely darkens the slow revolving moon.

This does not mean that all eclipses take place in the ecliptic plane. There are those seen from the earth with which the sun and moon have no connection.

The conical shadow cast by the sun has a length calculable by Rule of Three, because we know the distance of the earth from the sun, and the diameter of the sun and of the earth.

From the extremities of the solar diameter draw straight lines tangent to the earth. They will meet and form an isosceles triangle, the base of which is the diameter of the sun, 882,000 miles. This triangle is cut proportionally by the diameter of the earth, 8,000 miles, at a distance of 93,000,000 miles from the sun; round numbers being given for the sake of simplicity. Setting as x, unknown, the long side of the isosceles triangle, it is clear enough that the side of the conical shadow cast by the earth will be $x - 93{,}000{,}000$ miles. Solving the proportion, we get 93,851,258 miles for the long side, and taking from this the distance of the sun, 93,000,000 miles, we have 851,258 for the length of the shadow.

This shadow "lies floating on the floor," as it were, of the ecliptic plane, always, of course, turned away from the sun. The moon revolves about the earth, and supposing her always to be in the ecliptic, she would be, every time she came round, caught by this shadow and eclipsed; that is, would find her light, which is derived wholly from the sun, screened off from her. She falls into the shadow at a distance from the earth varying greatly, but averaging 240,000 miles; and, using the same triangles as before, 8,000 miles at 851,258 miles is 5,744 miles at 611,258 miles. For this distance of 5,744 miles, then, the moon is in "solid" shadow.

If the eclipse be central, that is, if she pass through the axis of the shadow, it will be two hours from the time of complete immersion before she begins to emerge on the eastern side. For though the moon moves eastward about her own diameter in an hour, and the shadow diameter is 2.6 of the moon diameter (the latter being 2,160 miles) yet, as a moment's pondering will show, her center at first internal contact will be at half her diameter within the shadow, and at second internal contact still half a diameter within the shadow. Her center, therefore, will be moving by the space of two diameters while she is wholly in a state of immersion.

If the moon moved in the ecliptic she would come into the earth's shadow once in every lunation, and would also come directly between the sun and the earth once in every lunation.

She does not, however, move in the ecliptic, but is in it, and below it, and above it at irregular intervals and at irregular distances. Sometimes, therefore, she avoids the shadow altogether, sometimes she skirts it lightly, and sometimes plunges wholly into it.

It should be clear from the above that eclipses of the moon are confined not only to the nodal epochs, but also to the times of opposition.

An eclipsed moon is always a full moon.

It rarely happens more than twice in the year that the moon is at one and the same time in opposition and near her node. Occasionally the unusual supervenes. In 1898, for example, there were three eclipses of the moon—two partial and one total.

The moon is visible to a whole hemisphere (nearly) at one time, and it is the hemisphere bounded by the line in which a cone with apex at the moon is tangent to the earth. The pole of this hemisphere will be a point somewhere on the parallel denoted by the moon's declination, and on the meridian of the observer; in short, where the moon can be seen in the zenith. This, as we already know, may be at any point within a zone lying equally on both sides of the ecliptic and 10 deg. 18 min. wide.

Suppose, now, the moon in her node at the first of Cancer, and full. This will place her on the meridian about midnight of the December solstice, and she will necessarily be totally eclipsed. Her center shall pass the axis of the shadow cone at midnight precisely on the meridian of Greenwich. And she will be 23 deg. 30 min. north of the equator.

Those living on the Tropic of Cancer will see her in the zenith, and the hemisphere will, at the moment chosen, be bounded by a circle whose plane is inclined 66 deg. 30 min. to the plane of the equator and is parallel to the horizon—which passes on the equator through 90 deg. east (Bay of Bengal) and 90 deg. west (Galapagos Islands, coast of Ecuador), and which touches the polar circles north (head of the Gulf of Anadir, eastern end of Siberia) and south (in the unknown Antarctic Continent). For those 90 deg. east of Greenwich the moon will be just setting in the west; for those 90 deg. west of Greenwich she will be just rising in the east. The others intermediate. All within the hemisphere described will see her at the point of centrality at the same instant of absolute time, which is recorded as one thing at one place and another thing at another. And it is only this hemisphere in question that can see the eclipse at the moment when it is central. For all the rest of the world the moon will at that moment be either not yet risen in the east or already gone down in the west.

It is clear from this that if the time of all the phases of an eclipse be accurately calculated for the meridian of Greenwich, or indeed for any other meridian, the hours and minutes of the calculation can be turned into the hours and minutes of any other meridian for which she may be above the horizon by adding or subtracting the known difference of longitude, which is time. And such, in fact, is the practice; since the Greenwich Nautical Almanac sets forth, among other things, the "elements" of every eclipse down to the hundredth part of a second.

Now when the center of the moon is on the axis of the shadow the moon has been wholly immersed one hour, and will so remain for another hour. It follows that those living 105 deg. to the eastward and to the westward of Greenwich (let us still say) can see the moon totally immersed.

Generally, therefore, when circumstances are favorable, a zone of 210 deg. of longitude is so favored.

If, now, we take into account the hour which the moon requires to get wholly into the dark and the hour which she requires to get wholly out again, it will appear that 24 deg. of longitude can see some part at least of the same total eclipse.

There are many circumstances which modify these statements to a small extent, but the general working of the system is correctly set forth.

We have supposed our conical shadow formed, as it were, by rays drawn tangent to sun and earth on the "same" side, upper side, so to speak, of both, western side of both, and so on. Now suppose rays drawn from upper side of sun to lower side of earth, from western side of sun to eastern side of earth, and so on. These rays will meet at a point between sun and earth—nearer to the latter. They will form a cone pointed in the direction exactly opposite to that of the *umbra*, or shadow, previously described. The portion of the cone on the far side of the earth will be in shadow, but shadow necessarily less dense than the other.

Penumbra, almost shadow, therefore:

The moon must traverse the penumbra before reaching the umbra, and may be seen to do so, the effect being that of a light smoke slowly spreading over her surface.

The moon when eclipsed in summer time appears pretty low down in the south; when in winter time, high up and nearly overhead.

If an observer were stationed at the apex of the earth's shadow he would see the sun not at all. The earth would eclipse the sun exactly—no more and no less. The dark side of the earth would be seen as a black disk with lighter edges. If the moon entered the earth's shadow she might perhaps be faintly made out.

The physical explanation of a lunar eclipse would thus seem to be an elementary matter enough, and that of a solar eclipse is not less so.

Once more for simplicity's sake supposing the moon to be moving in the ecliptic—she comes of necessity, once in a lunation, directly between the sun and the earth and her little conical shadow falls in the direction of the earth. Its dimensions are dealt with precisely as those of the earth's shadow, with simple change of data; and its average length is readily found to be 232,000 miles. As the moon's distance from the earth varies, the shadow is sometimes just long enough to reach the earth, and sometimes more than this, sometimes less.

Supposing as before an observer at the apex of this conical shadow; he would see the sun not at all—for the moon would blot out that luminary exactly, no more and no less.

If he went nearer to the moon, it is clear that he would go farther into the cone of the shadow, and that the moon would more than cover the sun. If, on the contrary, he went farther away, he would be clear of the shadow apex. The moon would not suffice to blot out the sun. A portion of the sun's disk would be visible around the black circle of the moon. All this is realized in fact; the only difference in the working being, that in consequence of the moon's varying distance from the sun, the point of the shadow cone falls short of the observer on the earth's surface, reaches him exactly, or passes beyond him several thousand miles into the body of the earth (as it were) and even beyond it on the other side. It must be clear that in the first case the observer sees an annular eclipse; in the second a total eclipse, lasting but for an instant, and in the last case a total eclipse lasting some little time.

We have now but to remember that the moon is sometimes in the ecliptic, sometimes above it, and sometimes below it. Hence the irregularly recurring solar eclipse. The moon comes to her nodes at periods irregular, but entirely calculable. Her shadow points at, reaches or more than reaches the earth at periods irregular, but entirely calculable. Whoever wishes to have the "figures" of an eclipse may find them in the almanac. The physical explanation of a solar eclipse is so readily set out by a little orderly thought that it is not easily lost when once acquired.

It is not usually realized that we see, to all intents and purposes, a total eclipse of the sun every time a cloud passes fairly across his face. The sun is obscured, and we see the moving shadow. And, indeed, the moon's shadow may be seen by those suitably raised above a level, far extended horizon. Its edge is plainly enough defined and it advances eastward with a very impressive velocity.

The moon's shadow, then, if it reach so far, is cut by the earth's surface at varying distances from the apex. It may be circular, if the shadow strikes the earth vertically, and may be from 160 to 170 miles in diameter at the intersection. Observers within the shadow see a total eclipse, with optical effects well calculated to terrify those who in old times beheld, but did not understand. The path of the shadow and the day, hour, and minute of its passing are calculated beforehand, and though the number of conditions to be taken into account makes the computation intricate, it is perfectly within the scope of ordinary mathematics.

If what was said just above regarding penumbra be remembered, it will suffice to say here, that the moon's shadow is precisely like the earth's in this respect, and that those within the penumbra see a partial eclipse instead of a total eclipse.

There are few that have not seen an eclipse of the sun, but very few that have seen a total eclipse. And yet there are those who will hear a new fact when they are told that about four solar eclipses happen for every three lunar eclipses. More than half the earth sees every lunar eclipse. But the track of the moon's shadow has a small width and length, which under favorable circumstances may make up about one two-hundredth part of the earth's surface. And even this does not mean that one man in two hundred sees the phenomenon of a total eclipse when it

* Proceedings of the Delaware County Institute of Science.

occurs; for the track may pass in great part over desert land or over the open ocean.

We have seen that the moon's diameter is 2,163 miles (nearly) and that she moves eastward about her own diameter in an hour. This, then, would be the rate at which the moon's shadow would pass the observer eastwardly. But the earth also is rolling eastward, and it is the difference in the two velocities which is observed. On the equator, therefore, 2,163 — 1,000 = 1,163 miles in an hour. In higher latitudes, where the surface of the earth moves with less velocity, the difference is greater. At 40 deg. north, for example, the velocity of the earth's surface is 766 miles in the hour, and the shadow would pass it at 1,397 miles per hour—2,949 feet in a second, the velocity of a cannon shot.

Now supposing the sun in Cancer when he is eclipsed, the shadow of the moon will fall upon the earth vertically at latitude 23 deg. 30 min. north. And we will suppose the shadow spot to have a diameter of 160 miles. Totality begins as soon as the shadow spot covers the observer and ends when it leaves him.

The earth turns eastward in 23 deg. 30 min. north at 923 miles per hour (nearly), so the shadow passes the observer at 1,240 miles per hour, and by Rule of Three will be about seven minutes and three-quarters in getting by. For so long the eclipse is total. It is easy to see that these results are modified in various ways by the time of day, the season of the year, by the latitude, and by other causes, all of which have to be taken into account in calculating the elements of a solar eclipse. The above is by no means the way in which the duration of a solar eclipse at a particular point is computed, but it is on the whole, perhaps, the best way of getting a general idea of the phenomenon.

The Nautical Almanac gives the several elements of a solar eclipse and a chart of its path. From these and his own observations the computer at one station and at another can work out the local results for himself.

THE ETHER OF SPACE.

A DISCOURSE BY SIR OLIVER LODGE.

SIR OLIVER LODGE, F. R. S., Principal of Birmingham University, had an overcrowded audience when lecturing on "The Ether of Space" at the Royal Institution.

Thirty years ago, Sir Oliver said, Maxwell had delivered an address on action at a distance in the same place. Most philosophers held that action at a distance was impossible, or, in other words, that matter could not act where it was not. The question, Where is matter? required more than a superficial answer. In one sense matter existed everywhere. Some philosophers believed that mind could act upon mind. That would not be action at a distance, however. The link between mind and mind might be quite other than matter, and those problems were, in his opinion, not physical, but of a different order of things. It was all mental action at both ends, but not necessarily brain action in between, somewhat analogous to heat transference by radiation.

In all cases of physical motion, Sir Oliver continued, we needed a medium, else transference could not occur. When we saw a weight moved by a magic wand, we looked for the string to which the weight was attached. It might be difficult to find the string, and when we had found it we were not at the root of the problem. Why did the whole rod follow when one end of it was pulled? That was not the best-known part of physics. Attraction across space needed a mechanism. A body moved when pushed from behind. We said that the horse pulled a car; but the horse really pushed against its collar. The explanation of cohesion involved a continuous medium connecting the discrete particles. A steel spring and a lath might be bent. But it was not the atoms of matter that were strained. It was the ether that was strained; matter could only be moved, displaced, re-arranged, but not strained, because there was no contact between matter and matter. The comet apparently rushing into the sun was seen to swing round it. The atoms of a metal were like the comets and planets of our solar system. Matter acted on matter only through the ether. But whether matter was specifically distinct from ether, or only a modified ether, was another question. The ether was an omnipresent continuous medium. It might be said to have been made in England, an exaggeration of truths largely built up in the Royal Institution. The lecturer proceeded to sketch out the chief lines of evidence of our knowledge.

In the "Queries" added to his "Opticks," Newton had asked: "Is not this æthereal medium much rarer in the denser bodies of the sun and stars than in the empty celestial spaces? and in passing from the bodies to great distances, doth it not grow denser perpetually, and thereby cause the gravity of those great bodies toward one another, and of their parts toward the bodies, every body endeavoring to go from the denser parts of the medium toward the rarer?" Sir Oliver passed to electrons, without explanation. The electron might be a point or a strain center in the ether; we did not know yet. But it was easy to suppose that the formation of such a center would involve a tendency to a slight rarefaction of the ether, very small indeed—since a real rarefaction would be impossible—for each electron, yet sufficiently strong in aggregates to produce extraordinarily powerful effects. The hypothetical tension of Newton per unit of matter would be small, but the force that held the moon in its orbit would be strong enough to tear asunder a steel rod 3,000 miles in diameter. If all the visible stars of Kelvin's estimate, reckoned equivalent to a thousand million suns, were concentrated in one body, the stress might be so great as to produce ethereal disruption of the universe into an enormous nebula, as the maximum stress in the interior would rise above 10^{22} dynes per square centimeter. Sir Oliver did not think that this had really happened, though there must be some reason why the matter of the universe was so scattered.

Referring to the undulatory theory of light advanced from the Royal Institution by Thomas Young a hundred years ago, the lecturer quoted Lord Salisbury's presidential address to the British Association at Oxford in 1894: "The function of the ether has been to furnish a nominative case to the verb 'to undulate.'" Faraday had devoted all his life to electromagnetic phenomena, which he considered as functions of the ether. One more function of the ether we had to study. It constituted matter. J. J. Thomson had summed up what we saw looming before us by stating that the whole mass of a body was the mass of the ether it carried along with it, and that this mass could be carried along by the (Faraday) lines of electric force, as well as the bodies these lines connected. All the mass, the momentum, and kinetic energy was that of the ether. The density of the ether was immensely greater than that of any substance we know. Compared to the ether, all our substances were mere gossamer, though a cobweb was neither unreal nor unimportant. What the density of the ether really implied the lecturer himself had only realized last summer.

Was the ether material? That was largely a question of words. It belonged to the material world; though it was not matter in the ordinary sense, it might be the substratum of which matter was made. An electron might be regarded as a knot in the ether; a knot in a string was composed of string, but the string was not composed of knots. There was an essential distinction: matter moved; the ether was strained, exerted stress, and recoiled. All potential energy was in the ether, which could vibrate and rotate, but was absolutely stationary, so to speak. All we could directly effect was to alter its configuration; everything else was indirect.

How was it possible that a solid could be made out of a fluid? A solid could be imitated by a fluid in motion. That had been a great part of Kelvin's work. A disk set with wooden spokes was transparent, so to say, when stationary, and rubber balls could be thrown through the spokes. When the wheel was spun round its axle, it became opaque, and the balls thrown at it recoiled back, as the audience saw. A jet of water falling from a great height on a Pelton wheel could not be cut through with a sword; the sword would break. Sir Oliver had only been informed of this experiment, but he repeated William Froude's instructive chain experiments. A cord of silk was suspended over a pulley which was rapidly turned. The cord became rigid, and a kink, produced in it with the aid of a stick, traveled down the cord very slowly only. In a chain the kink remained more stationary still. A rubber tire loosely fitting the pulley expanded more and more to a long loop hanging downward as the pulley was rotated; it quite retained a kink, and when finally jerked off the pulley, it ran down a piece of board, keeping the long loop shape like a rigid tube as long as the rotation continued. A disk of ordinary paper cut through a piece of cardboard like a circular saw when rapidly rotated.

Sir Oliver then showed vortex rings in a striking fashion. Some powdered cubeb was burned within a box, several feet cube; the box walls were rigid, but the back was made of canvas. The smoke issued from a hole in the front of the box when the lecturer tapped the canvas back with his hand. A round hole gave round stable rings, on which the light of the lantern opposite was thrown; these rings kept their shape as regards the vertical plane. When the hole was made elliptical, elliptical rings came out, and they twisted about peculiarly, as if made of rubber, demonstrating their theoretical instability. We owed, the lecturer said, most of our knowledge of vortex rings to Kelvin, though he had later abandoned his theory—to what extent, Sir Oliver could not say. He reminded the audience of Kelvin's gyrostatic model of an elastic body, four gyrostats so coupled up to a square frame that the whole, inclosed in a shell, would stretch under a weight like an elastic spring. Some day elasticity would be explained as the action of ether in motion, and that would be a fundamental thing.

How could we set the ether in motion? We could not spin it mechanically. Sir Oliver showed the photographs of the apparatus which he had tried. Two steel disks, a yard in diameter, had been fixed, an inch apart, on a vertical shaft, and four mirrors—the first one splitting the ray—had been so arranged close to the circumference that two rays traveled—the one to the right, the other to the left—through the air-cushion between the mirrors, to be reunited. Rotating the shaft at 3,000 revolutions per minute—as high a speed as he could risk—he had in vain looked for any evidence of interference between the two rays, although the machinery absorbed 10 horse-power and set up a terrific roar.* But we could make the ether vibrate by an electric charge, and every source of light was an electric charge in rapid motion, generating rapid waves in the ether. We could also make an electric charge spin by bringing it near a magnetic pole. This we could not prove directly. Indirectly we could, by moving the charge, that is, making an electric current flow parallel to a magnetic pole; the pole would then turn about the current. In the (Faraday) experiment shown the current flowed down a vertical wire and left through a finger dipping in an annular trough of mercury; the magnet was a thin vertical bar, bent in the plane of the trough, in its middle portion, where the wire shaft passed through it, the arrangement being such that the lower pole of the magnet was without the electric field. It was not so easy to eliminate the action of the lower pole, Sir Oliver remarked, and he was aware that the experiment could be explained in various ways. But he likened the observed effect to that of a gyrostat, a horizontal axis of which was weighted on the one side; the axis, it was shown, was not lowered, but it began to turn; and when a heavier weight was applied to the other end of the axis, the gyrostat reversed, just as the magnet did when the current was reversed.

The three vectors at right angles to one another—current, magnetic induction, and mechanical motion—Sir Oliver continued, represented the connection between electricity, magnetism, and mechanics; they explained dynamos and electric motors and light, and if we labeled them e, r, H, they were the uniting vectors of the universe. It looked, indeed, as if they pointed to the foundation of three-dimensional space. Matter now possessed another fundamental property, inertia; the ether likewise? A heavy pendulum could not be started by a sudden pull at a thin thread; the thread snapped, but it followed a slow, gentle pull. An electric current could not be started, nor stopped suddenly either; this was demonstrated in the following way: A Morse telegraph instrument was interposed between a battery and a reversing key; the two other terminals of the key were connected with a coil of a hundred turns, wound round a ring core, $2\frac{1}{2}$ inches in thickness, of iron wires. The self-induction of this coil delayed the click noticeably, particularly when a signal to the right was followed by one to the left, so that the magnetism of the core had first to be reversed; a lag of a good many seconds was thus produced, and had, in the laboratory, been prolonged to three minutes.

Now the mass of the electron had been measured by J. J. Thomson, and its size calculated. The mass associated with the electron might belong, not to itself, but to the fluid, and, to a certain extent, depend upon its velocity. In treating these problems, we might regard the electron as a sphere moving through a fluid, or as generating circular lines of magnetic induction by reason of the rotational properties of the ether, and attribute all the inertia to the magnetic whirl caused around its path. However we calculated the density—hydrodynamically, electrically, magnetically, or simply as density—the fluid appeared to be perfectly uniform,

* Sir O. Lodge did not refer to his experimental search for a possible magnetic drift of the ether.

and its density 10^{12}—i. e., about 50,000 million times that of platinum. Whether that figure were exact or not, the massiveness of the ether was certainly extraordinary. If, further, the ethereal elasticity were due to the motion of the ether, as it probably was, then the velocity accounting for the motion must be comparable with the velocity of the wave, just as the pulse or kink in the chain and tire experiments mentioned traveled down the chain with the velocity with which the chain was carried upward. The ethereal spin was therefore of the order of the velocity of light.

This density and this velocity enabled us to say that the intrinsic energy of a cubic millimeter of space was equivalent to the mass of 1,000 tons moving with the velocity of light [all the motion supposed to be internal and circulatory]. That would mean an output of a station of one million horse-power capacity working for forty million years. We were only beginning to investigate these matters, Sir Oliver stated in concluding his discourse. We could not experimentally verify those figures. What we did know was nothing compared to what we did not know. If it were asserted that the ether did not have any psychical significance, he was unable to agree.—Engineering.

THE ORIGIN OF CONTINENTS AND OCEANS.*

A THEORETICAL STUDY.

BY PROF. A. E. H. LOVE, F.R.S.

THE theory which has for more than a century been associated with the phrase "the figure of the earth" is the theory of the shape of the surface of the ocean. Apart from waves and currents, this surface is determined by the condition that there is no up and down upon it. This condition does not mean that the surface is everywhere at the same distance from the center of the earth, or even that it is everywhere convex, but that a body moving upon it neither rises against, nor falls in the direction of, gravity (modified by the rotation). A surface which has this character is called an equipotential surface, and the surface of the ocean coincides with part of an equipotential surface under gravity modified by the rotation. This particular equipotential surface runs underground beneath the continents. It is named the "geoid." The height of a place above sea-level means its height above the geoid. If we knew the distribution of density of the matter within the earth it would be a mathematical problem to determine the form of the geoid. As we do not know this distribution we have recourse to an indirect means of investigation, and the chief instrument of research is the pendulum. The time of vibration

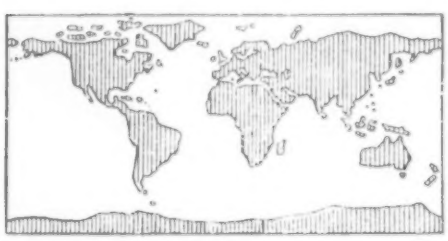


FIG. 1.

of a pendulum varies with the place where it is swung, and from the observed times we deduce the values of gravity at the various places, and it was shown many years ago by Stokes that the shape of the geoid can be inferred from the variation of gravity over the surface.

The question to which I wish to invite your attention is a different one. If the ocean could be dried up, the earth would still have a shape. What shape would it be? Why should the earth have that shape rather than some other? In order to describe the shape we may imagine that we try to make a model of it. If we could begin with a model of the geoid we should have to attach additional material over the parts representing land and to remove some material over the parts representing sea. Our model would have to be as big as a battleship if the elevations and depressions were to be as much as 3 or 4 inches. In thinking out the construction of such a model we could not fail to be impressed by certain general features of the distribution of continent and ocean, and we may examine a map to discover such features. Fig. 1 is a rough map of the world drawn in such a way that to

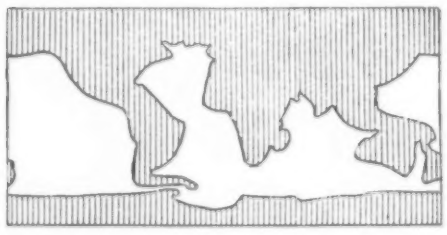


FIG. 2.

every degree of latitude or of longitude there corresponds the same distance on the map. Certain very prominent features have often been remarked: the tapering of America and Africa toward the south, the disproportion between the land areas of the northern and southern hemispheres, the excess of the oceanic area above the continental area, which occupies but little more than one-quarter of the surface; the wide extent of the Pacific Ocean, which with the adjoining parts of the Southern Ocean covers nearly two-fifths

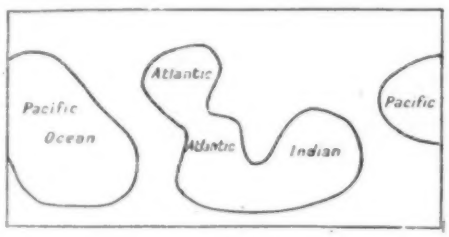


FIG. 3.

of the surface. Another prominent feature is the antipodal position of continent and ocean. South America south of an irregular line which runs from a point near Lake Titicaca to Buenos Ayres is antipodal to a portion of Asia which lies in an irregular triangle with corners near Bangkok, Kiaochau, and Lake Baikal; but no other considerable parts of the continental system have continental antipodes. The Antarctic continent is antipodal to the Arctic Ocean, Australia is antipodal to the central Atlantic, and so on. Another notable feature is the skew position of South America to the east of North America; South America lies to the east of the meridian 85 deg. west of Greenwich; most of North America lies to the west of it. But although we may observe prominent general features of the distribution, we should find it far from easy to attribute to the form of our imaginary model anything that could be called a regular geometrical figure. When we begin to think about the removal of material from the parts of the model which are to represent oceans and seas, we require a map which gives information about the depth of the sea in different places. Around all the coasts there is a margin

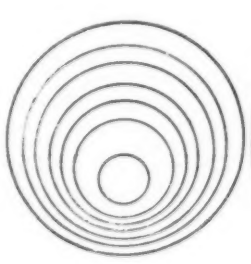


FIG. 4.

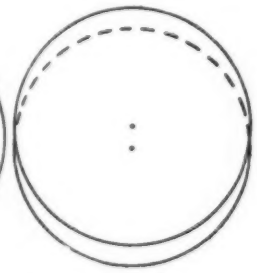


FIG. 5.

of not very deep water. If some part of the sea could be dried up, so that more land was exposed around all the coasts, the area of the surface of the sea would be diminished; and it is known that the depth of water that would have to be removed in order to make the area of the sea just half the total area is about 1,400 fathoms. The contour line at this depth would divide the surface into two regions of approximately equal area—the continental region and the oceanic region. Fig. 2 represents the contour line at 1,400 fathoms, or the line of separation of the continental and oceanic regions. The continental region is shaded. In drawing this map I have omitted a number of small islands, and I have also omitted a few inclosed patches of deep water. Two of these are in the Mediterranean, one in the Arctic Ocean, and others are in the Gulf of Mexico and the Caribbean Sea. The Red Sea, the Mediterranean, and the Arctic Ocean belong to the continental region, and so do the Gulf of Mexico and the Caribbean Sea. At this depth Asia and North America are joined across Behring's Strait, and Europe is joined to North America across the British Isles, Iceland, and Greenland; Australia is joined to Asia through Borneo and New Guinea, and the Australasian continental region nearly reaches the Antarctic region by way of New Zealand. At this depth also South America does not taper to the south, but spreads out, and is separated from the Antarctic region by a very narrow channel. By going down to great depths our problem is very much simplified. We find that the surface of the earth can be divided into continental and oceanic regions of approximately equal areas by a curve which approaches a regular geometrical shape. By smoothing away the irregularities we obtain the curve shown in Fig. 3, which exhibits the surface as divided up into a continuous continental region and two oceanic regions—the basin of the Pacific Ocean and the basin of the Atlantic and Indian Oceans. We may take our problem to be this: to account on dynamical grounds for the separation of the surface into a continental region and two oceanic regions which are approximately of this shape.

The key of the problem was put into our hands four years ago by Jeans in his theory of gravitational instability. If there are any differences of density in different parts of a gravitating body, the denser parts

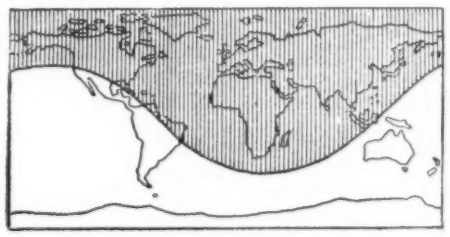


FIG. 6.

attract with a greater force than the rarer parts, and thus more and more of the mass tends to be drawn toward the parts where the density is in excess, and away from the parts where it is in defect. In every gravitating system there is a tendency to instability. In a body of planetary dimensions this tendency, if it were not checked, would result in a concentration of the mass either toward the center or toward some other part. But concentration of the mass means compression of the material, and it cannot proceed very far without being checked by the resistance which the material offers to compression. There ensues a sort of competition between two agencies; gravitation, making for instability, and the elastic resistance to compression, making for stability. Such competing agencies are familiar in other questions concerning the stability of deformable bodies. A long, thin bar set up on end tends to bend under its own weight. A steel knitting-needle a foot long can stand up; a piece of thin paper of the same length would bend over. In order that a body may be stable in an assigned configuration there must be some relation between the

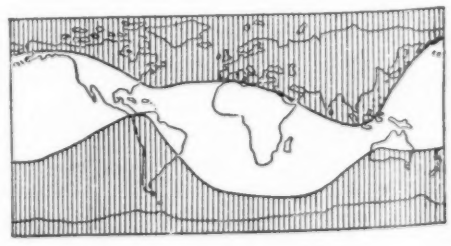


FIG. 7.

forces which make for instability, the size of the body, and the resistance which it offers to changes of size and shape. In the case of a gravitating planet we may inquire how small its resistance to compression must be in order that it may be unstable, and, further, in respect of what types of displacement the instability would manifest itself. If we assign the constitution of the planet, the inquiry becomes a def-

* An address delivered by Prof. A. E. H. Love, F.R.S., before the British Association for the Advancement of Science.

nite mathematical problem. The greatest difficulty in the problem arises from the enormous stresses which are developed within such a body as the earth by the mutual gravitation of its parts. The earth is in a state which is described technically as a state of "initial stress." In the ordinary theory of the mechanics

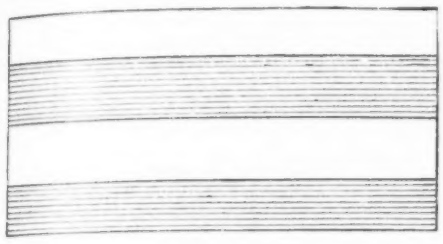


FIG. 8.

of deformable bodies a body is taken to be strained or deformed when there is any stress in it, and the strain is taken to be proportional to the stress. This method amounts to measuring the strain or deformation from an ideal state of zero stress. If the ideal state is unattainable without rupture or permanent set or overstrain, the body is in a state of initial stress. The commonest example is a golf ball made of India-rubber tightly wound at a high tension. Now the problem of gravitational instability can be solved for a planet of the size of the earth on the suppositions that the density is uniform and the initial stress is hydrostatic pressure. If the resistance to compression is sufficiently small the body is unstable, both as regards concentration of mass toward the center and as regards displacements by which the density is increased in one hemisphere and diminished in the other. A planetary body of sufficiently small resistance to compression could not exist in the form of a homogeneous sphere. It could exist in a state in which the surface is very nearly spherical, and the mass is arranged in a continuous series of nearly spherical thin

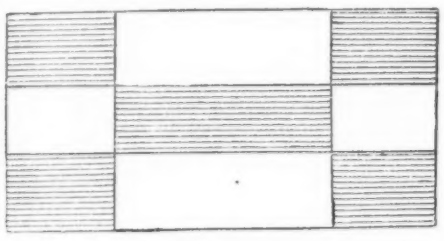


FIG. 9.

sheets, each of constant density; but these sheets would not be concentric. They would be crowded together toward one side and spaced out on the opposite side somewhat in the manner shown in Fig. 4. The effect would be a displacement of the center of gravity away from the center of figure toward the side where the sheets are crowded together. How small must the resistance to compression be in order that this state may be assumed by the body instead of a homogeneous state? The answer is that, if the body has the same size and mass as the earth, the material must be as compressible as granite. Granite, as we know it at the earth's surface, is not a typically compressible material. A cube of granite 10 feet every way could be compressed from its volume of 1,000 cubic feet to a volume of 999 cubic feet by pressure applied to every part of its surface; but according to the recent measurements of Adams and Coker the pressure would have to be rather more than two tons per square inch. A homogeneous sphere of the same size and mass as the earth, made of a material as nearly incompressible as granite, could not exist; it would be gravitationally unstable. The body would

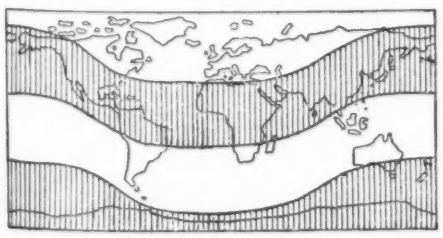


FIG. 10.

take up some such state of aggression as that illustrated in Fig. 4, and its center of gravity would have an eccentric position.

Now how would an ocean rest on a gravitating sphere of which the center of gravity does not coincide with the center of figure? Its surface would be a sphere with its center at the center of gravity (Fig. 5). The oceanic region would be on one side of the sphere and the continental region on the other side. It was pointed out many years ago by Pratt that the existence of the Pacific Ocean shows that the center of gravity of the earth does not coincide with the center of figure. There is no necessity to invoke some great catastrophe to account for the existence of the Pacific Ocean, or to think of it as a kind of pit or scar on the surface of the earth. The Pacific Ocean resembles nothing so much as a drop of water adhering to a greasy shot. The force that keeps the drop in position is surface tension. The force that keeps the Pacific Ocean on one side of the earth is gravity, directed more toward the center of gravity than the center of figure. An adequate cause for the eccentric position of the center of gravity is found in the necessary state of aggregation which the earth must have had if at one time it was as compressible as granite. The theory of gravitational instability accounts for the existence of the Pacific Ocean.

But we can go much further than this in the direction of accounting for the continental and oceanic regions. We keep in mind the eccentric position of the center of gravity, and try to discover the effect of rotation upon a planet of which the center of gravity

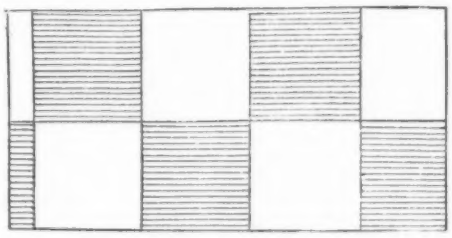


FIG. 11.

does not coincide with the center of figure. The shape of a rotating planet must be nearly an oblate spheroid; but the figure of the ocean would, owing to its greater mobility, be rather more protuberant at the equator than the figure of the planet on which it rests. The primary effect of the rotation of the earth upon the distribution of continent and ocean is to draw the ocean toward the equator, so as to tend to expose the Arctic and Antarctic regions. We have seen that both Arctic and Antarctic are parts of the continental region. But there is an important secondary effect. Under the influence of the rotation the parts of greater density tend to recede further from the axis than the parts of less density. If the density is greater in one hemispheroid than in the other, so that the position of the center of gravity is eccentric, the effect must be to produce a sort of furrowed surface; and the amount of elevation and depression so produced can be described by an exact mathematical formula. It has been proved that this formula is a sort of expression which mathematicians name a spherical harmonic of the third degree.

The shape of the earth is also influenced by another

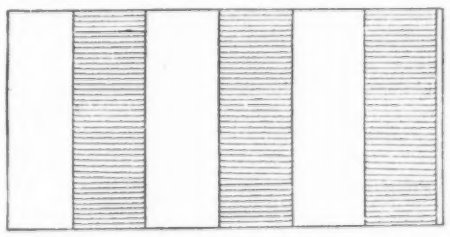


FIG. 12.

circumstance. We know that at one time the moon was much nearer to the earth than it is now, and that the two bodies once rotated about their common center of gravity almost as a single rigid system. The month was nearly as short as the day, and the moon was nearly fixed in the sky. The earth must have been drawn out toward the moon, so that its surface was more nearly an ellipsoid with three unequal axes than it is now. The primary effect of the ellipsoidal condition upon the distribution of continent and ocean would be to raise the surface above the ocean near the opposite extremities of the greatest diameter of the equator. But, again, owing to the eccentric position of the center of gravity, there would be an important secondary effect. The gravitational attraction of an ellipsoid differs from that of a sphere, and it may be represented as the attraction of a sphere together with an additional attraction. If the density was greater in one hemi-ellipsoid than in the other, the additional attraction would produce a greater effect in the parts where the density was in excess, and the result, just as in the case of rotation, would be a furrowing of the surface. It has been proved that the formula for this furrowing also is expressed by a spherical harmonic of the third degree.

We are brought to the theory of spherical harmonics and the spherical harmonic analysis. Spherical harmonics are certain quantities which vary in a regular fashion over the surface of a sphere, becoming positive in some parts and negative in others. They specify standard patterns of deformation of spheres. For instance, we might remove material over one hemi-

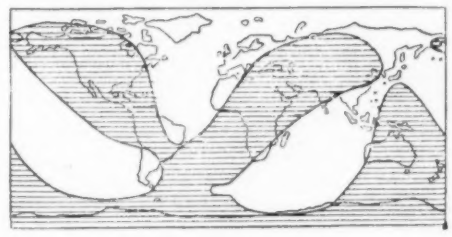


FIG. 13.

sphere down to the surface of an equal but not concentric sphere (Fig. 5) and heap up the material over the other hemisphere. We should produce a sphere equal to the original but in a new position. The formula for the thickness of the material removed or added is a spherical harmonic of the first degree. It specifies the simplest standard pattern of deformation. Again, we might remove material from some parts of our model and heap it up on other parts so as to convert the sphere into an ellipsoid. The formula for the thickness of that which is removed or added is a spherical harmonic of the second degree. Deformation of a sphere into an ellipsoid is the second standard pattern of deformation. The mathematical method of determining the appropriate series of standard patterns is the theory of spherical harmonics. Its importance arises from the result that any pattern whatever can be reached by first making the deformation according to the first pattern, then going on to make the deformation according to the second pattern, and so on. If we begin with a pattern, for instance the shape of the earth, which is not a standard pattern,

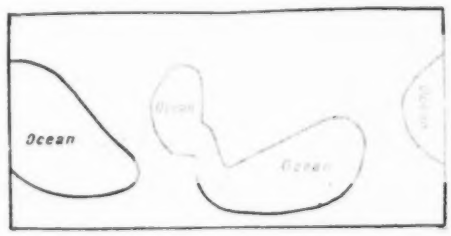


FIG. 14.

we can find out how great a deformation of each standard pattern must be made in order to reproduce the prescribed pattern. The method of doing this is the method of spherical harmonic analysis. With much kind assistance and encouragement from Prof. Turner, I made a rough spherical harmonic analysis of the earth's surface. I divided the surface into 2,592 small areas, rather smaller on the average than Great Britain, gave them the value + 1, or one unit of elevation, if they are above the sea, and the value —1, or one unit of depression, if they are below the 1,400-fathom line. To the intermediate areas I gave the value 0. The distribution of the numbers over the surface was analyzed for spherical harmonics of the first, second, and third degrees.

Any spherical harmonic of the first degree gives us a division of the surface into two hemispheres—one elevated, the other depressed. The spherical harmonic analysis informs us as to the position of the great circle which separates the two hemispheres, and also as to the ratio of the maximum elevation of this pattern to the maximum elevation of any other pattern.

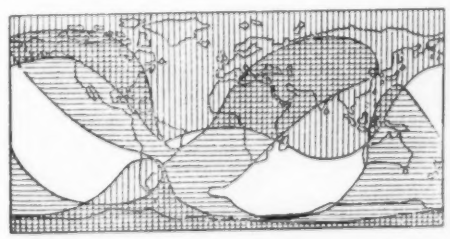


FIG. 15.

The central region of greatest elevation of this pattern is found to be in the neighborhood of the Crimea in Russia, on the shores of the Black Sea, and the region of elevation contains the Arctic Ocean and the northern and central parts of the Atlantic, Europe, Africa, Asia, most of North America, and a small part of South America. When the surface is mapped on a rectangle in the same way as before, the chart of the

harmonic is that shown in Fig. 6.* The actual disproportion between the amounts of continental area in the northern and southern hemispheres is associated with the result that the central region of elevation, as given by the analysis, is about 45 deg. north of the equator; and the extension of the Pacific Ocean and adjoining Southern Ocean to much higher southern than northern latitudes is associated with the corresponding position of the central region of greatest depression about 45 deg. south of the equator. In regard to harmonics of the second degree, the spherical harmonic analysis informs us as to ellipticity of the equator and the obliquity of the principal planes of that ellipsoid which most nearly represents the elevation of the surface above or its depression below the surface of the ocean, or the geoid. The result is an equatorial region of depression, which spreads north and south unequally in different parts and forms a sort of immense Mediterranean, containing two great basins, and separating a northern region of elevation from a southern. The northern region of elevation occupies the northern part of the Atlantic Ocean and runs down to and across the equator in the neighborhood of Borneo. The southern region of elevation occupies the southern part of the Pacific Ocean, and it runs up to and across the equator in the neighborhood of Peru. The chart of the harmonic is shown in Fig. 7. The equatorial regions of elevation given by the analysis are near the ends of a diameter, as we should expect.

It has not been necessary to enter into a minute description of the harmonics of the first and second degrees, because they represent very simple things—a shifting of the surface to one side and a distortion of it into an ellipsoid. The harmonics of the third degree are not so familiar. There are essentially four of them, each specifying a standard pattern of deformation. The first of these, the zonal harmonic, gives us a division of the surface into two polar caps and two zones by means of the equator and the parallels of latitude about 51 deg. north and 51 deg. south. Alternate zones are depressed and elevated, as shown in Fig. 8. The existence of an Antarctic continent and an Arctic Ocean is specially associated with the presence of this harmonic, and the disproportion of the continental areas in the northern and southern hemispheres is also connected with it. The second of the harmonics of the third degree, the tesseral harmonic of rank 1, gives us a division of the surface into six half-zones by means of a complete meridian circle and the parallels of latitude about 27 deg. north and 27 deg. south. Alternate half-zones are depressed and elevated as shown in Fig. 9. The combined effect represented by the zonal harmonic and the tesseral harmonic of rank 1 is a furrowed surface with an Arctic region of depression extending southward in the direction of the Atlantic, a zone of elevation which runs across the Atlantic, South America, and Africa, and then turns northward at either end, a zone of depression with the same kind of contour, and an Antarctic region of elevation which extends northward in the direction of Australasia. These regions are shown in Fig. 10. I have recorded the result of combining these two harmonics because they represent the particular effects that would be produced by the interaction of two causes—the rotation and the eccentric position of the center of gravity. The third type of harmonics of the third degree, the tesseral harmonic of rank 2, gives us a division of the surface into octants by means of the equator and two complete meridian circles. Alternate octants are elevated and depressed as shown in Fig. 11. We can name the octants where there is elevation: Asia, Australasia, North America, South America. The harmonic of this type is certainly prominent. It is specially associated with the skew position of South America to the east of North America. The fourth type of harmonics of the third degree, the sectorial harmonic, gives us a division of the surface into six sectors by means of three complete meridian circles. Alternate sectors are depressed and elevated as shown in Fig. 12. The southward tapering of Africa is specially associated with the harmonic of this type. The combined effect of all the harmonics of the third degree is shown in Fig. 13.

When we superpose the effects represented by all the various harmonics of the first, second, and third degrees, so as to make, as it were, a composite photograph of all the various elevations and depressions represented by them severally, each in its appropriate amount as determined by the harmonic analysis, we find the curve shown in Fig. 14 as the theoretical curve of separation between regions of elevation and depression which are approximately equal in area. I showed before a smoothed curve (Fig. 3) which I proposed to take as representing the facts to be accounted for. The resemblance of the two curves seems to be striking. Incidentally it has been noticed how the prominent features of the distribution of continent and ocean are associated with the presence of various harmonics. As regards the contour of the great ocean basins, we seem to be justified in saying that the earth is approximately an oblate spheroid, but more nearly an ellipsoid with three unequal axes, having its surface furrowed according to the formula for a certain spherical harmonic of the third degree, and displaced relatively to the geoid toward the direction of the Crimea.

As regards the amount of elevation and depression in different parts, the agreement of the theory with the facts is not so good. The computed elevation is too small in Southern Africa, Brazil, and the southern part of South America, too great in the Arctic regions, to the south of Australasia, and in the Mediterranean region. There are many reasons why we could not expect the agreement to be very good. One is the roughness of the method of harmonic analysis that was used. But there is also the fact that many causes must have contributed to the shaping of our actual continents and oceans besides those which have been taken into account in the theory. It appears, however, that the broad general features of the distribution of continent and ocean can be regarded as the consequences of simple causes of a dynamical character; eccentric position of the center of gravity, arising from a past state of inadequate resistance to compression, an inherited tendency, so to speak, to an ellipsoidal figure, associated with the attraction of the moon in a bygone age, the rotation, and the interactions of these various causes.

In attempting to estimate the bearing of the theory on geological history we must be guided by two considerations. The first is that the earth is not now gravitationally unstable. From observations of the propagation of earthquake shocks to great distances, we can determine the average resistance to compression, and we find that this resistance is now sufficiently great to keep in check any tendency to gravitational instability. The eccentric position of the center of gravity must be regarded as a survival from a past state in which the resistance to compression was not nearly so great as it is now. The second guiding consideration is that, according to the theory, the inequalities which are expressed by spherical harmonics of the third degree are secondary effects due to the interaction of the causes which give rise to inequalities expressed by harmonics of the first and second degrees. We should expect, therefore, that the inequalities of the third degree would be much smaller than those of the first and second degrees; but the harmonic analysis shows that the three inequalities are entirely comparable. We must conclude that the harmonics of the first and second degrees which we can now discover by the analysis are survivals from a past state, in which such inequalities were relatively more important than they are now. Both these considerations point in the same direction, and they lead us to infer that certain changes may have taken place in the past, and may still be going on. A symptom of such changes might be the occurrence of great subsidences in the neighborhood of the Crimea, where we found the maximum of the first harmonic. Such subsidences are supposed by geologists to have taken place in rather recent times. Symptoms of the diminution of the inequalities expressed by harmonics of the second degree would be found in the gradual disappearance of seas forming part of the great depression which was described above as a sort of immense Mediterranean (Fig. 7), in the destruction and inundation of a continent in the northern Atlantic and in a gradual increase of depth of the Southern Pacific. The disappearance of seas from a vast region surrounding the present Mediterranean basin, and containing the Sahara and Southern Asia as far east as the Himalayas, is one of the best ascertained facts in geological history; and the belief in the destruction of a north Atlantic continent is confidently entertained. In parts of the Southern Pacific a depression represented by harmonics of the third degree is superposed upon an elevation represented by harmonics of the second degree, and we should therefore expect to find the depth of the ocean to be increasing gradually in this region. The region in question is that of the coral reefs and coral islands, such as Faunafuti, and the result is in accord with Darwin's theory of the formation of coral reefs. So far as the general distribution of the mass within the earth is concerned, the reduction of the inequalities of the first and second degrees would seem to have already proceeded very far; for we are assured by geodesists that harmonics of the first degree, and those of the second degree which do not represent the effect of the rotation, are far from prominent in the figure of the geoid—much less prominent than we found them to be in the distribution of continent and ocean. We infer that the inequalities of the first and second degrees must have been progressively diminished in comparison with those of the third degree. The general result of such changes would be a gradual diminution of the depths and extents of the oceans which correspond with the harmonics of the first and second degrees, and a compensating increase in the depths and extents of the oceans which correspond with the harmonic of the third degree. To see the character of the changes which would thus be brought about, we may examine a figure which shows the composite elevations and depressions that are represented by harmonics of the first and second degrees, and, separately, those which are represented by harmonics of the third degree. In Fig. 15 the composite elevations of the first and second degrees are shaded vertically, and the elevations of the third degree are shaded horizontally. The deep parts of the Atlantic that border the coasts from Brazil to Ashanti are regions in which a depression represented by the third harmonic is superposed upon an elevation represented by the other two harmonics, and the same is true of the deep parts of the Indian Ocean which border the shores of Africa and Asia from Madagascar to Burmah. The deep parts of the Pacific that border the western coast of America from Alaska to Chili are regions in which an elevation represented by the third harmonic is superposed upon a depression represented by the other harmonics. These observations suggest that in the greater part of the Atlantic and the northern and western parts of the Indian Ocean the direction of secular change may have been that of an advance of the ocean to encroach upon the continental region, while in the Pacific Ocean on the American side the direction of secular change may have been that of a retreat of the ocean, permitting an extension of the continental region. This difference would lead us to expect different types of coast in the two regions, and such a difference has been observed. Whereas in the Atlantic region, with few exceptions, the coast cuts across the directions of the mountain chains, in the Pacific region on the American side the coast generally corresponds in direction with the neighboring mountain chains of the continent. The deep parts of the Pacific which are nearest to the Asiatic coast from Kamchatka to Siam are regions where a moderate depression represented by the third harmonic is superposed upon a moderate elevation represented by the other harmonics. These shores of the Pacific are distinguished by the wide margin which separates the deep ocean from the coast of the continent. It might perhaps be desirable to recognize in this region a type of coast differing from the two main types associated with the Atlantic and the American side of the Pacific. The analysis does not represent South Africa or the southern parts of South America sufficiently well to warrant us in expecting these regions to exhibit one type rather than the other; but the way in which Australia is represented, as an elevation of the third degree superposed upon a depression of the first, suggests that the coasts of Australia, and especially the eastern coast where the elevation in question is greater, should be of the same type as the American shores of the Pacific; and it is the fact that the mountain chains of Queensland and New South Wales run parallel to the neighboring coasts. There seems therefore to be much evidence to support the view that the direction of secular change has been that of diminishing the prominence of the inequalities of the first and second degrees in comparison with those of the third degree. The process by which such changes would be brought about would be of the nature of relief of strain, expressing itself in occasional fractures of no very great magnitude; and such fractures would be manifested at the surface as earthquakes. Seismic and volcanic activities constitute the mechanism of the process of change. These activities are spasmodic and irregular, but the effect of them is cumulative. For this reason they tend in the course of ages to transform the shape of the earth from one definite type to another. The diminishing speed of the earth's rotation is another cause of change which appears to produce an alternating rather than a cumulative effect. On the one hand it tends to diminish that tendency, which we noted above, to draw the waters of the ocean toward equatorial regions; on the other hand it must result in an actual reduction of the equatorial protuberance of the earth's figure. This reduction can only be effected by seismic activity expressed by subsidences in equatorial regions. The effect which would in this way be produced in the distribution of continent and ocean would appear to be that there would be long periods in which the ocean would tend to advance toward the Arctic and Antarctic regions, interrupted by shorter periods in which it would tend to retreat toward the neighborhood of the equator.

The theory is a tentative one, and further investigation may prove it to be untenable; but it is to its credit that, besides tracing to dynamical causes the existing distribution of continent and ocean, it offers an explanation of the difference between the Atlantic and Pacific types of coast, it gives indications of a possible account of those alternations of sea and land which first led to the study of geology, and suggests an origin for Charles Darwin's unknown force the operation of which is slow and intermittent, but irresistible.

* In this figure, and in the subsequent figures, regions of elevation are shaded, and regions of depression are left blank.

Protective Poultry Powder Against Vermin.—304 parts of mountain ash berries, 24 parts oyster shells, 4 parts pepper, 3 parts paprika.

THE HISTORY OF GLASS MAKING.*

THE ANCIENT ORIGIN OF GLASS.

BY GEORGE A. MACBETH.

ALL evidence tends to the undeniable first appearance of glass in Egypt. In no place else in all the world has its prior use been discovered, either in the form of a glaze, a paste, or a true glass.

We can imagine the easy invention or discovery of making a cup out of mud or clay, which when dried would hold liquid; also of the further burning of this cup, by which its hardness and usefulness as a containant of liquid was greatly increased. This is a common utensil the world over and more than likely was discovered by other nations besides the Egyptians. But the discovery or invention of glazing was quite a different matter, as it is closely related to the smelting of copper ore, and would not be discovered by a nation unfamiliar with this art. This, however, the Egyptians practised at a very early period. Nowhere else in the world do we find prior to 3,000 to 4,000 years B. C. remains of copper glass or glaze; at which time, however, the Egyptians were mining and smelting copper at mines on the Sinaitic peninsula,† notwithstanding the fact that in historic times Egypt was not known as a timbered country, nor a country where fires were used sufficient to fuse a glass.

From the very first dawn of history, the flint arrowhead was in evidence, and next to this pottery, unglazed but ornamented. Speaking in a general way, copper is the next thing in prehistoric times, flints being used side by side with copper tools from the fourth to the twelfth dynasties; but not until a long time after the appearance of copper does glazed pottery make its appearance, preceded by glazed stone. All of this early glazing indicates by its color, which is blue or bluish green, in the case of some more exposed pieces darker green, the unmistakable presence of copper, and analysis shows a good percentage of this metal. Considering the composition of this glaze, as well as the composition and color of the oldest piece of glass, we see how closely the glazing of pottery and the discovery of glass are associated with the smelting of copper and how this association centers around the mines of the Sinaitic peninsula, where copper mines were worked from three to four thousand years B. C. This glaze may be considered the first glass, and this first glass, it is to be noted, was a colored glass long before the discovery of a clear, transparent glass. The operation of the copper mines at Sinai must have been quite extensive for the times, for Lepsius states that he examined and walked over a bed composed entirely of copper slag, 250 paces long and some 30 to 120 paces wide, and several feet in depth. The operation of these mines was carried on by the builders of the tombs of Beni Hasson, the dating of the tombs being about the twelfth dynasty, or about 2,500 years B. C.

If we place ourselves in the position of one who has never seen a piece of glass of any description, it does not require a great stretch of imagination to picture the curiosity which would have been displayed at this discovery; a piece of slag, not so hard as agate or flint, but capable of being polished, and which could be cut as a seal, or made into a bead, both very important in the Egyptian customs and practices in all times. The number of scarabs and small images found, dating from somewhat before this period, and on for thousands of years, is most astonishing. They have been made out of various substances, but a piece of glass-like copper slag, and a glass-like mixture later, would have been a most admirable substance to use for this purpose, and undoubtedly it was so used.

In one of the tombs of Beni Hasson is a picture of two men blowing into a fire through metal pipes or what may be reed pipes tipped with clay. These have been supposed to be glass blowers, and, if so, the date at which glass blowing was known in Egypt must be set back several hundred years. But, though accepted by archæologists and scholars the world over, until within a comparatively recent period, doubt has been thrown upon the fact of their being glass blowers by Mr. Griffith, who is entitled to the greatest respect, and regarded as of the highest authority.‡

For it seems from what we learn from another place in the same volume, that there are no remains of *blown* glass at that early period, which is undoubtedly correct. And since blown glass could not have been made without leaving some remains, it does appear as if these men could not be blowing glass. Remains of glass are among the very oldest things we have, and until such are found of blown glass, we are obliged to doubt that these men are glass blowers. But one thing is evident, they are blowing into a fire, either to make it hotter, to melt metal or for some other reason, and no matter which, it gives us a hint as to how glass blowing was most likely discovered.

About 1300 B. C. we find the remains of a glass crucible or pot, being a shallow vessel some twelve inches in diameter, made of clay. We find not only the crucible itself, but the glass of such form that it is clear that it had been melted in a crucible.

Now, if the Egyptians were familiar with the use of the blowpipe for increasing the heat of the fire for fusing metals, they would undoubtedly do the same thing for the fusing of copper slag, or copper slag mixed with alkali; indeed, we are not left to conjecture about this, copper slag that had been melted in a crucible being among the finds.

Now, having the molten glass in the crucible, we can easily see that if the blowpipe, be it of reed or metal, should by accident or design happen to be dipped into the molten glass and then blown in, we have the discovery of blown glass; not an invention at all; perhaps, indeed, the mischievous trick of an idle boy, one of such who, in defiance of all rules, have made some of the greatest inventions of the world.

From the first appearance of glass-like copper slag at Beni Hasson or Thebes, at 2500 B. C., until the period of 1300 B. C., say a thousand years (a length of time which we can hardly appreciate), progress in the development of the art of making glass was very slow; but during all of this time the manipulation of melting various small pieces and making small articles and fusing them together into one piece was carried on, and the specimens as we find them in our museums show quite clearly the direction the development was taking.

About 1300 B. C., as has been stated, remains of [illegible] The rods indicate the idea of pulling out the pieces fused together like taffy. Thus we find pieces of glass in which the figure of a bird, say, passes through the piece from end to end, the various colors and forms being continuous, although often of microscopic proportions.

This has led to great astonishment on the part of the learned ignorant of glass working. It has been extolled as a "lost art" to which modern civilization was unequal; but it is nevertheless very simple and is performed every day by the confectioner when he unites different colored candy together and draws it out, or when a single word or motto traverses the whole stick. The "secret" being simply that, as the candy is pulled out, all parts of the stick or figure diminish in size proportionally.

Pliny gives a well-known account of the discovery of glass by Phœnician sailors who built a fire on the sand with which some soda was mixed.

Now this account is untenable, and we note that Pliny does not give it other than as a story he had heard. On the other hand, it is not to be wondered at that such a relation should become current, considering that Egypt was not a timber-producing country, there being no occasion there for furnace fires, or fires other than for the most necessary domestic use; while Phœnicia was heavily timbered and its people, the great traders of the world at that period, were accustomed to the use of fires and became the glass makers of the world after the Egyptians.

From the copper glaze of the tombs of Beni Hasson to the making of a true glass occupied what to us would be a very long time, that is, about 1,000 years. The mixture of alkali from the Natron lakes (in the vicinity of Alexandria) with a substance like copper slag, developed into nearly what we know as glass, the first pieces being altogether opaque, showing the insufficient heat and insufficient alkali or flux. The decomposition of pieces found is exactly what would happen to glass made this way. The Phœnicians at this period, being almost the exclusive traders with the Egyptians, appropriated the art. And from this time forth glass marks the trend of commerce and the tracks of the first navigators of the then known world. Timber abounded in Phœnicia, as has been said; its people were accustomed to fires, and had besides a better knowledge of chemistry and more chemicals than any other people of antiquity. But, as Pliny states, a certain white earth obtained from Egypt, i. e., natron (carbonate of soda), from the Natron lakes, was necessary to make glass at Sidon. The Phœnicians were also acquainted with the alkali carbonate of potash obtained from the ashes of seaweed.

Much has been said regarding the imitation of agate and other stones. The glass-maker, accustomed to the making of colored glasses, knows full well the many and curious pieces, much resembling agate and many other stones, which he encounters by accident, and the first pieces of glass were probably more like agate than not; their streaks of copper and iron earth or ore are not intentional, but incidental to the state of the art.

It is worthy of note that the reason for so many remains of glass-making being found, i. e., fragments of colored glass, in Egypt and Phœnicia is caused by the impossibility of fusing the various colored pieces again, and producing any certain color. The art, however, was perfected by the Phœnician glass-makers and the remains of their glass show them masters of the art of blowing clear, uncolored, and colored glass; molded, and made "offhand." They were the first to put glass handles on glass vessels, and all of the glass found in Greece and Cyprus, which was formerly called Greek glass, is Phœnician. Examples of this can best be seen in the Jarvet collection in the Metropolitan Museum, and has been treated extensively by Froehner in his catalogue of this collection.

To treat particularly of the history of glass from this time forth would require volumes, and space forbids entering into the history of the manufacture of it from this date to the present time, which would involve its manufacture by the Phœnicians and its spreading thence to the Netherlands to France and England.

* From the Proceedings of the Engineers' Society of Pennsylvania.

† Lepsius, "Egypt, Ethiopia, and Sinai," p. 22.

‡ This illustration can be found in "Egyptian Exploration Fund," vol. iv., "Beni Hasson."

BRANLY'S EXPERIMENTS WITH ELECTROLYTIC COHERERS.

[illegible] made in his laboratory at Paris, the transmitter and receiver were distant 150 feet in a straight line, being installed in two rooms separated by four walls. The transmitting spark between the balls of the instrument was 0.08 inch in length, and was given by a small induction coil, reinforced by placing a zinc plate in connection with one of the balls and using an 8-foot mast. The receiving circuit comprised a battery, electrolytic coherer, and telephone, with a mast of variable height. By means of a revolving drain, a series of contacts were made with the induction coil so as to give a short phrase in Morse characters which was constantly repeated. The coherer had a positive electrode of 1/2,500 inch diameter and used current from a storage battery. It was heated in a water-bath up to 80 deg. C. At 30 deg. there was already a marked increase in the sound in the telephone. This rose and reached a maximum at 60 deg., then decreased slightly to 80 deg. After heating for several times the sensitiveness was lost to a great extent, but this reappeared after six months. Other experiments were made to show the effect of mechanical shaking. The best way was to agitate the coherer as a whole, using a clockwork movement for the purpose, while the noise of the clockwork was shut off by a wall. In some cases the operator at the telephone could set the clockwork in movement at a distance by means of an electromagnet. It was found that the sound in the telephone was always increased by the shaking of the coherer and this effect lasts as long as it is agitated, sometimes even keeping up afterward for some time. The greatest effect is obtained by sending a stream of gas into the electrolyte of the coherer, using a fine tube which leads the gas into the central part, with pressures of 4 or 5 atmospheres. The flow is regulated by a stop cock, observing the passage of the gas bubbles. As soon as the gas flows in the coherer, an increase of sound is noticed in the telephone, and this effect often remains for a long time after the flow of gas has stopped. Should it have lessened, however, a new supply of gas will again cause an increase. The same effect is given by gas which is given off from two heavy platinum wires placed in the liquid with a current passed in them. Coherers were used having wires of 1/2,500, 1/1,250, and 1/500 inch diameter. Another experiment showed that by using two coherers in series instead of a single one the effect in the telephone is increased, outside of any other influence. In this case the battery current must be raised in proportion.

SCIENCE NOTES.

A German physician reports the fatal poisoning of two insane persons by soap which they had contrived to obtain. One of them died an hour, the other two days, after eating an ordinary cake of soap. Chemical analysis of the soap failed to reveal the presence of any distinctly poisonous ingredient, so that the fatal effects must be attributed to the action of the soap as such, although the mucous surfaces that came into contact with it were not greatly inflamed. The force of the heart's beat was much diminished before death ensued. These cases, which are believed to be the only ones of the kind ever reported, illustrate the danger of intrusting either insane persons or children with objects of daily use and apparently harmless character.

It is well understood to-day that all the phenomena of life are to be explained on the basis of chemical and physical laws, and it is partly because of a clear recognition of this fact that biological chemistry has finally attained the eminence it has now reached as a division of biology; a branch of study that promises much in the ultimate explanation of many of the most intricate of the present-day problems of life. There is another reason why biological chemistry has shown such remarkable development during the past decades, and that is because of the direct aid it has furnished, and still promises to furnish, to physiology and to both experimental and practical medicine. Physiology as an independent science, having to do with the study of function, has grown in keeping with the increasing demand for wider knowledge of the processes of life, and this has led quite naturally to a broader recognition of the importance of the chemical side of physiology, since the physical side has been found inadequate to explain all the varied phenomena of living organisms. As a result, physiological chemistry has developed by leaps and bounds, until to-day special laboratories and journals devoted to this subject are to be found on all sides.

A patent has been issued to Dr. Henry Spencer Blackmore, an industrial chemist of Washington, D. C., for converting natural gas into alcohol. Manufacturing interests of the United States are making inquiry to the Bureau of Manufactures in regard to this new method of producing alcohol, and the following abstract of a letter from Dr. Blackmore is therefore presented: "I have devised a process of converting natural gas, which contains on an average 96 per cent ...thane, into alcohol by the action of limited portions of oxygen or air in the presence of a heat-absorbing fluid, such as steam, which prevents complete combustion and maintains the temperature below the decomposing point of alcohol, the oxidation being induced and maintained by passing the gaseous ingredients through an electrically heated gauze. By subjecting natural gas to a limited or restrained oxidation or combustion in this manner, it is converted directly into alcohols and dehydrogenated alcohols known as aldehydes, the aldehyde of methane alcohol (wood alcohol) being known as formaldehyde. The product, therefore, is a mixture methyl alcohol, containing a small portion of formaldehyde, which can be readily separated. If the combustion is properly regulated and controlled, 5,000 feet of natural gas will produce approximately 50 gallons of alcohol, and as natural gas can be readily obtained in unlimited quantities at from 5 to 10 cents per thousand feet, it follows that the cost of 50 gallons of alcohol produced in this manner would only be 25 to 50 cents for raw material."

A new compound has been prepared by M. Marcel Guichard, of Paris, this being the tetra-iodide of uranium. To carry this out he uses a sealed vacuum tube in which iodine is heated to 180 deg. C. and its vapor can thus act upon metallic uranium which is also contained in the tube. After heating, the new compound collects upon the cooler parts of the tube. It appears as a crystalline mass, or in other cases is made up of blackish needle crystals in an assembled mass. The melting point of this body is 500 deg. C., and it is not easily volatilized at 500 to 600 deg. *in vacuo*. Its density is 5.6 at 15 deg. C. Analysis shows it to have the composition $U I_4$. As to its chemical properties, when heated in hydrogen, it gives off iodine slowly, with formation of hydriodic acid. Chlorine gas decomposes the new compound, and it becomes heated during the operation. When still further heated, trichloride of iodine is given off as a sublimate and there remains chloride of uranium in the form of a black, melted mass. When heated in dry hydrogen, it glows and gives off iodine, being transformed to the green oxide of uranium. This same effect takes place when the body is heated in dry air. When it is kept for some length of time in dry air, it becomes covered with small black crystals of iodine, and also absorbs air. In a moist atmosphere it is oxidized and also by the action of water vapor. A fragment of this compound when left in the open air becomes rapidly deliquescent and forms a brown liquid containing iodine. It dissolves easily in water.

ENGINEERING NOTES.

The construction of a huge new waterway across Siberia, nearly parallel with the course of the Trans-Siberian Railway, is projected in Russia. It is proposed to connect five great Siberian rivers—the Tobol, Ishim, Irlish, Ob, and Yeniessei—and other less important streams, by canals or light railways, and with a view to this the Russian government has ordered extensive surveys to be taken.

The production of denatured alcohol for the first six months of 1907, under the new law covering its manufacture, amounted to 1,774,272 gallons. The supplemental new alcohol law will, it is estimated, lead to a production of 4,000,000 gallons for the calendar year. The operation of the law has already reduced the cost of wood alcohol from prices varying between 60 and 75 cents to 30 cents a gallon, a fact which amply indicates that a fairly efficient monopoly has been established in the wood alcohol business.

The passage of the free alcohol bill by Congress did not carry with it such enormous immediate changes in its use in the industries as was predicted, nor did the price of denatured alcohol fall to anything like the figures intimated. There are, however, strong indications that alcohol finally will become cheap enough to enter into active competition with gasoline and kerosene for a variety of power purposes. It has been shown by a congressional committee investigating the matter that the total cost of producing a gallon of 90 per cent alcohol at a large distillery in Peoria, Ill., is 18.4 cents. This, however, was when producing alcohol directly from corn. A far cheaper price may be reached by producing alcohol from potatoes, or even from the stalks of corn and corn cobs. In Cuba alcohol is now made from a cheap grade of molasses, which ordinarily is a waste product, at a cost of 10 cents a gallon, and there is no good reason why we may not ultimately expect the same low level of price to be reached in the United States. If the price were right, alcohol would, for many reasons, be far preferable to any of the common liquid fuels for power purposes.

A project which has lately appeared in Italy consists of connecting Rome with the seacoast by an avenue of 15 miles length and 250 feet width which will start from the Basilica of St. Paul and end at Castel Fusano. In the middle of the avenue will be a strip of 28 feet width on which it is proposed to lay out a double-track railroad. On this line will circulate express trains only which will run at 60 miles an hour, and they will cover the distance from Rome ' ' the coast in 20 minutes. At the side of the line there will be built a second double-track road which is used for local passenger and freight traffic. On one side of the four tracks there will be laid out a wagon road of 25 feet width and a 15-foot sidewalk, while on the other side is a special route for automobiles having 35 feet width. It will be divided into two parts by a fence in the middle so as to direct the circulation both ways. A bicycle and horse road will run along the latter route, having 25 feet width. It will also be divided into two parallel parts. There will also be laid out a second vehicle route with a sidewalk, which will complete the entire width of the strip in question. At different points there will be erected railway stations or platforms of large size, and there will be a series of underground passages for making connection between the two station platforms and also others for passing from one of the above-mentioned routes to another, seeing that there will be no grade crossings on the present line.

The new line of railroad which is now being built in China from Nanking to Shanghai is well under way. It is of English construction and was commenced in the latter part of 1903. In laying out the plans of the road it was desired to follow the valleys of the different streams of the region as much as possible. Starting from Shanghai, the road proceeds along the valley of the Su-Chau River, then follows the line of the Grand Canal. From Chin-Kiang it will follow the river Yang-tse-Kiang. Owing to the numerous rivers which are crossed by the present line there are a great number of bridges to be built, and in the portion lying between Shanghai and Su-Chau there are no less than 111 bridges over a distance of 50 miles, making over two bridges per mile. In the case of these bridges, a large span must be provided so as to allow for the passage of junks, which are quite numerous on all the streams of the country. Some important cuts and fills had to be carried out from Wushieh to Chin-Kiang. When approaching Nanking the river bed is of such nature that it will be too difficult to place bridge piers at this point, so that a ferryboat service will be used instead. As regards the construction of the track, it is of standard gage and of the usual English type, being of very strong build. The grades do not exceed 0.7 per cent along the present line. The line has but a single track, using rails which weigh 70 pounds per yard laid upon ties of Australian jarrah wood. A second track will, however, be laid from Shanghai to Su-Chau at a later period, and the road construction has been laid out with this end in view.

TRADE NOTES AND FORMULÆ.

To Tin Textiles.—Mix commercial zinc dust with a solution of egg albumen into a thin paste, apply it, allow it to dry, coagulate the albumen by means of hot steam, then place it in a solution of chloride of tin. Wash in water, dry, and finish.

Quick-Drying Floor Polish.—Dissolve 1 part of shellac in 2 to 2.5 parts of 90 per cent alcohol, adding 1 to 2 per cent of copaiba balsam (or Venice turpentine) and a sufficient quantity of umber and ocher. Apply the color with a shoe brush to the wood. The addition of 0.5 per cent of boiled linseed oil to the mixture improves its elasticity. If the wood has been covered as desired, a coat of clear varnish can be given to increase its polish.

To Silver Textiles.—Two solutions. 1. Caustic lime 2 parts, sugar 2 parts, syrup or honey 5 parts, water 650 parts, gallic acid 2 parts; filter and preserve in carefully corked bottles. 2. Nitrate of silver 20 parts, ammonia 20 parts, distilled water 50 parts. When using, mix both solutions. Cleanse the fabric, dip it into the solution of gallic acid, then in one of silver salt and water. Repeat the operation. Then dip in the above double composition, boil in tartaric acid solution, wash and dry.

Electro Deposit of Metal on Flowers and Insects.—The objects in question are dipped in an albuminous fluid to protect them, by this coating, from the metallization. Hereupon they are dipped in a bath of about 20 per cent nitrate of silver solution and exposed to the effects of hydrogen sulphide gas in order to reduce the nitrate of silver present to metallic silver. Everything is now ready for the electro deposit. Hereby the slightest unevennesses of the surface are revealed, and with the naked eye, hardly visible hairs can be plainly distinguished from one another.

Bright Gold: Its Production for the Purpose of Porcelain and Glass Gilding.—Ten parts of gold heated in 60 parts of nitric acid and 120 parts of hydrochloric acid in a water bath. To the mixture, when the gold is completely dissolved, add 2 parts of tin and 2 parts of chloride of antimony, and when this is dissolved, 500 parts of water. By heating, also dissolve 16 parts of sulphur and 16 parts of Venice turpentine in 30 parts of oil of turpentine, and to the balsamic, brown mixture thus obtained, add 50 parts of oil of lavender, to prevent the separation of the sulphur. On this sulphur balsam, the gold solution is poured, the mixture heated and slowly stirred, effecting the combination of the gold with the mass. On cooling, the mixture forms a resinous mass, which, after washing several times with warm water, receives an addition of 65 parts of lavender oil and 100 parts of oil of turpentine, after which the whole is heated until it forms a clear solution and is then left to settle. The bright gold, when used, is concentrated by evaporation until it forms a thick fluid with a greenish reflection.

Baking of Molding Sand.—The two most important components of molding sand are quartz-sand and clay. On the proportion of these to each other and the fineness of the sand its usefulness for molding purposes depends. The quantity of clay must not be so large that the molding sand, when heated to slight red heat, as it is likely to be when in contact with the molten metal, becomes very hard. Nevertheless, there must be enough clay so that the sand when moistened and pressed together will cohere firmly. By the addition of lampblack or pulverized charcoal, the baking or caking of molding sand may be prevented, while the addition of beer yeast, beer, syrup, rye flour, etc., will promote this action. The presence of lime in molding sand is injurious. Practicable molding sand is found in many places and for use requires only reduction and removal of small stones by screening. It may be artificially produced from 93 parts of pure quartz sand and 7 parts of clay, free from lime. Molding sand that has been used can be restored to its original cohesiveness by mixing with new sand. Molding sand should not be kept in the open air, because the rain washes out the fine clay particles.

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